Calendar No. 205

100TH CONGRESS *1st Session*	SENATE	REPORT 100-87

NASA AUTHORIZATION ACT, 1988

Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

together with

ADDITIONAL VIEWS

OF THE

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ON

S. 1164

JUNE 24, 1987.—Ordered to be printed

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Calendar No. 205

100TH CONGRESS
1st Session

SENATE

REPORT
100-87

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, 1988

JUNE 24, 1987.—Ordered to be printed

Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

together with

ADDITIONAL VIEWS

[To accompany S. 1164]

The Committee on Commerce, Science, and Transportation, to which was referred the bill (S. 1164) to authorize appropriations to the National Aeronautics and Space Administration for research and Development, space flight, control and data communications, construction of facilities, and research and program management, and for other purposes, having considered the same, reports favorably thereon with an amendment in the nature of a substitute and recommends that the bill do pass.

PURPOSE OF THE BILL

The purpose of this bill is to authorize appropriations to the National Aeronautics and Space Administration (NASA) totaling $9,621 million for fiscal year 1988, as follows:

	Budget request	Committee authorization
Fiscal year 1988:		
Research and development	$3,623,200,000	$3,721,000,000
Space flight, control, and data communications	4,064,300,000	4,081,300,000
Construction of facilities	195,500,000	210,700,000
Research and program management	1,598,000,000	[1]1,608,000,000

[1] Includes $10 million authorized in title II for Space Grant College and Fellowship Program

Legislative History

In January, 1987, the Administration submitted its fiscal year 1988 budget request for NASA. The Committee considered budget and related policy matters in hearings on January 22, February 3, February 19, February 26, March 5, and April 29. The Committee received testimony from the NASA Administrator and NASA officials associated with major agency programs, the Secretary of the Air Force, the Director of the Office of Commercial Space Transportation, and the space science and aerospace communities.

On May 7, 1987, Senators Riegle and Pressler introduced S. 1164, a bill to authorize appropriations for the National Aeronautics and Space Administration. On May 8, Senator Riegle introduced S. 1173, a bill to authorize appropriations for the Office of Commercial Space Transportation. Both of these measures were introduced at the request of the Administration. On May 14, the Committee met in executive session and unanimously ordered reported S. 1164 with an amendment in the nature of a substitute. The amendment reported by the Committee also incorporated the language of S. 1173 (the Office of Commercial Space Transportation FY 1988 Authorization), S. 502 (Technical Amendments to the Land Remote-Sensing Commercialization Act of 1984), S. 503 (the Shuttle Gifts and Donations Bill), S. 504 (Reestablishment of the National Aeronautics and Space Council), and S. 752 (the Space Grant College and Fellowship Program).

NASA AUTHORIZATION SUMMARY

[In millions of dollars]

	Fiscal year		Proposed fiscal year 1988 Senate authorization
	1987 operating plan	1988 request	
I. Research and development	(3,120.7)	(3,623.2)	(3,721.0)
1. Space station	420.0	767.0	767.0
2. Space transportation capability development	491.1	568.6	592.6
Spacelab	(73.9)	(73.5)	.....
Upper stages	(156.1)	(159.7)	(181.7)
Engineering and technology base	(133.4)	139.8)	.....
Payload operations and support equipment	(44.5)	(83.4)	(85.4)
Advanced programs	(27.6)	(24.9)	.....
Tethered satellite system	(10.6)	(7.3)	.....
Orbital maneuvering vehicle	(45.0)	(80.0)	.....
3. Space science	983.4	940.0	973.7
A. Physics and astronomy	(552.8)	(567.1)	(591.8)
Hubble space telescope development	101.3	98.4	.....
Gamma ray observatory development	50.5	49.1	.....
Shuttle/Spacelab payload development	90.1	95.4	.....
Explorer development	56.7	60.3	80.3
Mission operator and data analysis	125.7	128.1	.....
Research and analysis	53.4	60.1	.....
Suborbital program	75.1	75.7	80.4
B. Life sciences	(72.2)	(74.6)	(74.6)
C. Planetary exploration	(358.4)	(307.3)	(307.3)
Galileo development	71.2	55.3	.....
Magellan	97.3	59.6	.....
Ulysses	10.3	10.8	.....
Mars observer	35.8	29.3	.....

NASA AUTHORIZATION SUMMARY—Continued

[In millions of dollars]

	Fiscal year		Proposed fiscal year 1988 Senate authorization
	1987 operating plan	1988 request	
Mission operations and data analysis	75.8	77.0	
Research and analysis	68.0	75.3	
4. Space applications	569.2	559.3	651.4
A. Solid Earth observations	(75.6)	(76.8)	(80.8)
Shuttle/Spacelab payloads	21.6	21.1	
Geodynamics	32.1	33.1	
Research and analysis	21.9	22.6	26.6
B. Enviornmental observations	(320.9)	(393.8)	(393.8)
Applied research, data analysis and related activities	142.8	141.3	
Shuttle/Spacelab payload development	12.0	19.4	
Scatterometer	32.9	22.7	
Upper atmosphere research satellite [UARS]	114.2	95.4	
Ocean topography experiment [TOPEX]	19.0	90.0	
Global geospace science	0	25.0	
C. Materials processing in space	(47.9)	(45.9)	(50.0)
D. Communications	(103.5)	(20.5)	(104.5)
E. Information systems	(21.3)	(22.3)	(22.3)
5. Commercial programs	40.9	54.0	49.0
Technology utilization	(15.7)	(18.3)	(18.3)
Commercial use of space	(25.2)	(35.7)	(30.7)
6. Aeronautical research and technology	374.0	375.0	375.0
Research and technology base		(285.2)	
Systems technology programs		(89.8)	
Rotocraft systems technology		5.0	
High-performance aircraft systems technology		14.6	
Advanced propulsion systems technology		30.5	
Numerical aerodynamic simulation		39.7	
7. Transatmospheric research and technology	45.0	66.0	66.0
8. Space research and technology	168.0	250.0	212.0
9. Safety reliability and quality assurance	12.0	16.2	16.2
10. Tracking and data advanced systems	17.1	18.1	18.1
II. Space flight control and data communications	(5,799.5)	(4,064.3)	(4,081.3)
1. Space shuttle productions/operations capability	1,005.1	1,229.6	1,150.6
Orbiter operational capability		(403.2)	(324.2)
Launch and mission support		(249.3)	
Propulsion systems		(552.1)	
Changes and systems upgrading		(25.0)	
2. Replacement orbiter	2,100.0		
3. Space transportation operations	1,847.0	1,885.8	1885.8
Flight operations	(557.7)	(561.1)	
Flight hardware	(936.0)	(923.1)	
Launch and landing operations	(353.3)	(401.6)	
4. Space tracking and data acquisition	845.4	948.9	944.9
Space network		(481.5)	
Ground network		(257.1)	
Communications and data systems		(210.3)	
5. Expendable launch vehicle operations	2.0	0	100.0
III. Construction of facilities	(166.3)	(195.5)	(210.7)
IV. Research and program management	(1,460.5)	(1,598.0)	[1] (1,608.0)
Total NASA	10,547.0	9,481.0	9,621.0

[1] Includes $10 million authorized in title II for Space Grant College and Fellowship Program.

Summary of Major Provisions

For fiscal year 1988, the Committee would authorize $9,621,000,000 for NASA, and $4,550,000 for the Office of Commer-

cial Space Transportation. Of this, $3,721,000,000 is authorized for research and development, $4,081,300,000 for Space Flight Control and Data Communications. In addition, $210,700,000 is authorized for Construction of Facilities, and $1,608,000,000 for Research and Program Management, including the $10 million authorized in title II of the National Space Grant College and Fellowship Program.

The Committee provides $767,000,000 to initiate Phase C/D activities with the intent that actual hardware development activities will begin in this fiscal year. This represents no change from the fiscal year 1988 budget request of the Administration.

The Space Transportation Capability Development budget of $592,600,000 represents a $24,000,000 increase over the fiscal year 1988 NASA budget request. This increase will provide for the development of the upper stage and payload operations necessary to accommodate the Advanced Communications Technology Satellite (ACTS), which is scheduled for launch in November 1990.

The Committee authorizes $973,700,000 for Space Science activities, which is $24,700,000 above the Administration's budget request. $20,000,000 of this increase will provide additional funds for the Explorer Development program. The additional $4,700,000 of the increase will be directed at the suborbital programs to increase flight opportunities in this productive area. The Planetary Exploration and Life Sciences programs are funded at the level of the President's budget request for fiscal year 1988, $307,300,000 and $74,600,000 respectively.

The Committee authorizes $651,400,000 for Space Applications programs compared with the President's budget request of $559,300,000. The Committee increases funding for Materials Processing in Space by $4,100,000 to increase the development of flight hardware. The Committee augments the Solid Earth Observations budget to establish capabilities for receiving directly from foreign remote sensing satellites data collected over the United States. The Committee also provides $84,000,000 for the Advanced Communications Technology Satellite (ACTS) program, for which no funding was requested by the Administration. Other programs, such as the Upper Atmosphere Research Satellite (UARS), the Ocean Topography Experiment (TOPEX), and the Global Geospace Science program (the only new start included in the budget request) are authorized at the levels of the President's budget request.

The Committee has authorized $49,000,000 for NASA's commercial programs, a $5,000,000 reduction from the requested level.

In the Aeronautical Research and Technology programs, the Committee authorizes $375,000,000 which is identical to the Administration's request.

Transatmospheric Research and Technology is also authorized at the requested level of $66,000,000.

NASA requested $250,000,000 for Space Research and Technology in fiscal year 1988, including $134,100,000 for the Civilian Space Technology Initiative (CSTI). The Committee authorizes $212,000,000 for these programs. The $38,000,000 reduction anticipates that in fiscal year 1988 the Department of Defense will fund duplicative propulsion technology activities to be undertaken by NASA as part of the Advanced Launch System program. This re-

duction is without prejudice since the Committee strongly endorsed the CSTI initiative.

The Committee authorizes $16,200,000 for Safety, Reliability and Quality Assurance, and $18,100,000 for Tracking, and Data Advanced Systems. Both of these programs are funded at the requested funding level.

The total Research and Development budget for fiscal year 1988 is $3,721,000,000, compared with a budget request of $3,623,200,000, and a fiscal year 1987 operating plan of $3,120,700,000.

The Committee authorizes $4,081,300,000 for Space Flight, Control and Data Communications for fiscal year 1988 compared to the President's budget request of $4,064,300,000. Of this amount $1,150,600,000 is for Space Shuttle Productions and Operations Capability, $1,885,800,000 for Space Transportation Operations, $944,900,000 is for Space Tracking and Data Acquisition, and $100,000,000 is for Expendable Launch Vehicle Operations.

The Administration requested $1,229,600,000 for fiscal year 1988 for Space Shuttle Production/Operations Capability. The Committee authorizes $1,150,600,000 for these activities. The Committee deleted funding for Space Shuttle structural spares, which totals $79,000,000, until such time as NASA's use of expendable launch vehicles is resolved and the Nation's space transportation requirements are thoroughly identified.

The Committee authorizes $1,885,800,000 for Space Transportation Operations, the President's request. However, the Space Tracking and Data Acquisition request is reduced by $4 million to $948,900,000. This is a general reduction to be made at the discretion of the Administrator of NASA.

In addition, the Committee authorizes $100,000,000 to initiate the procurement of Expendable Launch Vehicles despite the fact these funds were not requested.

In fiscal year 1988, the Committee authorizes $210,700,000 for Construction of Facilities, compared to the requested level of $195,500,000. The Committee, without prejudice, defers initiation of Space Station Construction of Facilities activities until 1989, resulting in a reduction of $25,800,000, and authorizes Phase I of the repair and rehabilitation of the Ames Research Center 12 foot pressure wind tunnel which results in an increase of $41,000,000. The deferral of space station facilities projects adjusts this schedule to the most recent Administration proposal.

The Research and Program Management account would be increased $10,000,000 over the NASA request of $1,598,000,000. This increase would accommodate initiation of the Space Grant Fellowship program contained in Title II. The total authorization for Research and Program Management would be $1,608,000,000 in fiscal year 1988.

The total authorization for NASA in fiscal year 1988 is $9,621,000,000, compared with the President's budget request of $9,481,000,000 and the fiscal year 1987 operating plan of $10,547,000,000.

The Committee also has included $4,550,000 in S. 1164 for the activities of the Office of Commercial Space Transportation. This meets fully the request submitted by the Administration and compares with $1,245,000 in fiscal year 1987.

I.—RESEARCH AND DEVELOPMENT—$3,721,000,000

The Committee authorizes $3,721,000,000 for research and development activities in fiscal year 1988. This is $97.8 million greater than the President's fiscal year 1988 request.

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology; to develop and improve manned and unmanned space vehicles; and to assure continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals. These objectives are achieved through the following elements:

Space Station.—A program to develop a U.S. Space Station to continue the Nation's leadership in space and to provide for enhancement of science and applications programs and to further the commercial utilization of space while stimulating advanced technologies.

Space Transportation Capability Development.—A program to provide for the development and use of capabilities related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts related to the development and flight certification of the jointly development U.S./Italy Tethered Satellite System, development of the Orbital Maneuvering Vehicle, development and operations of the Spacelab systems, the development and procurement of upper stages that place satellites in high altitude orbits, the engineering and technical base support at NASA centers, payload operations and support equipment, and advanced programs study and evaluation efforts.

Space Science and Applications.—A program using space systems, supported by ground-based and airborne observations, (1) to conduct a broad spectrum of scientific investigations to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and intersellar space, the stars of our galaxy and the universe; and (2) to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in the solution of Earth resources and environmental problems.

Technology Utilization.—The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology, and development programs.

Commercial Use of Space.—A program to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development.

Aeronautics and Space Technology.—A program to conduct the fundamental long-term research and to develop the discipline and systems technology required to maintain United States leadership in aeronautics and space.

Tracking and Data Advanced System.--This program includes activities to perform studies and provide for the development of systems and techniques leading to improve tracking and data program capabilities.

Research and development budget summary

[In millions of dollars]

	Proposed fiscal year 1988 Senate authorization
I. Research and development	(3,721.0)
1. Space station	767.0
2. Space transportation capability development	592.6
3. Space science	973.7
A. Physics and astronomy	(591.8)
B. Life sciences	(74.6)
C. Planetary exploration	(307.3)
4. Space applications	651.4
A. Solid Earth observations	(80.8)
B. Environmental observations	(393.8)
C. Materials processing in space	(50.0)
D. Communications	(104.5)
E. Information systems	(22.3)
5. Commercial programs	49.0
6. Aeronautical research and technology	375.0
7. Transatmospheric research and technology	66.0
8. Space research and technology	212.0
9. Safety reliability and quality assurance	16.2
10. Tracking and data advanced systems	18.1

A. Space Station—$767,000,000

The Committee authorizes $767,000,000 for fiscal year 1988 for the Space Station program. This is the same as the President's fiscal year 1988 budget request.

Summary of fiscal year 1988 funding levels

Development	$733,000,000
Pressurized modules	(196,500,000)
Assembly hardware/subsystems	(204,000,000)
Platforms and servicing	(59,000,000)
Power system	(88,000,000)
Operations capability/utilization	(52,000,000)
Management and integration	(133,500,000)
Flight telerobotic system	22,00,000
Operations	7,000,000
Transition definition	5,00,000
Total space station	$767,000,000

The Space Station will provide a unique capability to enhance the Nation's space science and applications program and to further the commercial utilization of space while stimulating advanced technologies. Development of the U.S. permanently manned Space Station, as directed by President Reagan, will follow a deliberately paced program plan which will permit us to maintain the preeminence in space our Nation has attained through various manned and unmanned programs.

The U.S. Space Station will be a multi-purpose, national facility, providing a permanent human presence in space to conduct essential scientific and technical research, to support unique commercial

activities, and to perform operational tasks more efficiently in space. International participation with the U.S. Space Station program has been encouraged by the President. Canada, member states of the European Space Agency (ESA), and Japan have responded enthusiastically. Memoranda of Understanding (MOU) for the definition and preliminary design phase were executed with Canada, ESA, and Japan in the Spring of 1985 concurrent with the initiation of the NASA definition contracts. These international partners have undertaken parallel definition and preliminary design studies to identify Space Station elements that each of them may consider for development. Negotiations for the development phase of the program are currently under way with our current international partners.

The Space Station will be designed to permit the system to evolve, as warranted, over time to provide greater user utility and operational capabilities. Its manned and unmanned elements will be designed to facilitate on-orbit maintainability/restorability, operational autonomy, human productivity, and simplified user interfaces. Implicit in these objectives is the recognized need to optimize man/machine systems in space via automation, robotics, and artificial intelligence technologies.

Based on President Reagan's announcement of April 3, 1987, the final decision on the cost configuration and schedule of the space station program will not be determined until after the NASA proposal is thoroughly reviewed by the National Research Council's (NRC) Committee on the Space Station, which is chaired by Robert Seamans. The Council's report is due on September 1, 1987, and the final proposal should be included in the fiscal year 1989 NASA budget request. The most recent NASA space station proposal would implement the program in two phases—Block I and Block II. Block I would commence in fiscal year 1988, and cost an estimated $12.2 billion (1984 constant dollars). Block II would commence in fiscal year 1991, and cost an estimated $3.8 billion (1984 constant dollars). The first space station hardware would be launched in March 1994, and the proposed U.S. space station would become permanently manned in the 1996 time frame.

The Station and its platforms will be placed and maintained in low-Earth orbit by the Space Transportation System, thereby building upon the previous national investment in space. However, the use of a heavy lift launch vehicle or advanced launch system for the space station is also under review by NASA.

The definition and preliminary design phase will continue through fiscal year 1987 and will provide the technical and programmatic plan for the Space Station development program, including the completion of the detailed definition and preliminary design, the analysis and integration of national and international user community requirements, and the advanced development of technology options. A continuing emphasis on user requirements and operations will be maintained as the engineering design evolves through subsystem advanced development and testing in dedicated test beds.

The fiscal year 1988 budget provides for the buildup of Space Station development activities initiated with funding approved in the fiscal year 1987 appropriation. The rate at which the buildup of

these activities will occur will be somewhat reduced from last year's projection as a result of the configuration review and changes and the resulting delay of the request for proposals release. In addition to this effort, an in-depth assessment of the Space Station's management structure has been completed, and implementation of the recommendations is well under way. The key elements of the program are now baselined and ready to proceed.

The development phase will not be initiated until fiscal year 1988, although funds were provided to initiate these activities in fiscal year 1987. The development phase includes the prime contractor effort on the work packages, which will provide the major hardware components. Pending the outcome of on-going negotiations, supporting development activities such as the systems engineering and integration (SE&I), the program's Technical and Management Information System (TMIS) and Software Support Environment (SSE), and the evolvement of operational planning including user accommodations and interfaces could still be initiated in fiscal year 1987. Based on the current NASA Space Station Office schedule, the contract awards for the major hardware components should be awarded by November 1987. The TMIS, SE&I, and SSE contract awards are scheduled for the May–July 1987 time frame.

Space Station—Committee Comments

As an indication of the Committee's strong support of the development of a permanently manned space station, the Committee authorizes $767 million for the space station program, which is identical to the President's budget request. The Committee anticipates that by this Fall a final space station configuration will have been approved and these monies will be used to aggressively initiate Phase C/D of the program—the hardware/development phase.

Despite the Committee's strong support of the space station program, the Committee is concerned about the degree of confusion and lack of commitment that has become apparent within the Administration to develop a permanently manned space station. Recent events have unnecessarily caused a great deal of consternation and unacceptable delays in the U.S. space station program. At the same time key White House officials are debating whether or not to build a space station and the proposed cost, schedule, and configuration, the Soviets have a permanently manned space station that circles the globe every ninety minutes. The Committee believes that it is time for the U.S. to realize that our leadership in space has significantly eroded, and, if certain measures are not taken, our space program could experience a significant reduction in vitality and effectiveness.

The Committee is optimistic that the National Research Council's review of the cost, schedule and configuration of the space station program will resolve the outstanding issues with only marginal changes to the NASA proposal and will help the Administration commit to a single, clearly defined concept. Once the concept has been agreed upon, the Committee hopes the Administration will manifest its commitment to the program with a commensurate request for resources in the fiscal year 1989 budget submission. The Committee is concerned that currently the only budgetary commit-

ment the Administration has made to the space station program is for fiscal year 1988–90. This creates some uncertainty as to the degree of commitment to and scope of the program beyond fiscal year 1990.

This Committee has long supported a balanced space program and continues to see the space station as a critical element of that program. However, the Committee does not see the space station as an end in and of itself. Rather, it is a means to accomplish basic scientific goals and space research. The Committee, therefore, expects to see a sustained commitment to NASA's other research and development activities, especially space science and applications and aeronautics.

The Committee is strongly committed to the belief that the space station project should advance the state of technology—specifically, technologies that can be spun-off for ground-based applications or that improve the performance and economics of space-based activities. For this reason, the Committee has been most supportive of the space station advanced technology initiatives, in particular automation and robotics and the solar dynamic power system. Concerning the latter, the Committee instructs NASA to continue within available fiscal year 1988 funding the preliminary design activities for the development of solar dynamic power. In parallel with these activities, NASA is instructed to initiate the development of solar dynamic hardware that will permit this advanced technology to be incorporated into the space station program if the "full up" or "phased program" is agreed to in fiscal year 1989.

The Committee maintains its belief that the space station is a facility that should be used for peaceful purposes in accordance with international law. Accordingly, the Committee has incorporated language in the fiscal year 1988 bill which reaffirms this position. The same language was included in the fiscal years' 1985, 1986, and 1987 Senate bills and restates Article IV of the 1967 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Celestial Bodies.* Pursuant to this standard, the Department of Defense is perceived to be a user of the space station, and it is recognized that it may conduct research and development activities on the space station facilities.

The Committee recognizes that an important element of the international negotiations over the use of the space station is the issue of national security related activities. The Committee understands that the current negotiating record in this regard has been clearly established and that all utilization will be for peaceful purposes consistent with international law, including utilization for national security purposes.

The Committee is deeply concerned about the extent and degree of preceived interagency differences of opinion as to the character and role of the proposed space station. Final resolution of this issue is critical to the successful completion of international negotiations and to final Congressional approval of the space station program. The fact that the current space policymaking apparatus does not appear to have been able to resolve these interagency differences is cause for serious concern.

Finally, the Committee is concerned that nearly $150 million of fiscal year 1987 space station funding remains frozen pursuant to report language contained in the fiscal year 1987 HUD-Independent Agencies Appropriations Bill (H.R. 99-731). The Committee feels it is absolutely essential that NASA and the Appropriations Committees resolve this issue in a timely manner. These monies are required to initiate critical support, non-prime contracts in fiscal year 1987, including the Technical Management Information System (TMIS), the Software Support Environment (SSE), and the Program Support Contractor (PSC) that could substantially enhance the implementation of the space station program in fiscal year 1988. The Committee expects to the kept well informed of any development in this area and in any other area pertaining to the space station program.

B. Space Transportation Capability Development—$592,600,000

The Committee authorizes $592,600,000 for fiscal year 1988 for space transportation capability development. This is $24 million greater than the President's budget request in order to accommodate the launch of the Advanced Communications Technology Satellite (ACTS) in 1990. The President requested no funds in fiscal year 1988 for ACTS.

Summary of fiscal year 1988 funding levels

Spacelab	$73,500,000
Upper stages	181,700,000
Engineering and technical base	139,800,000
Payloads operations and support equipment	85,400,000
Advanced programs	24,900,000
Tethered satellite systems	7,300,000
Orbiting maneuvering vehicle	80,000,000
Total space transportation capability development	592,600,000

The principal areas of activity in Space Tranportation Capability Development include the Spacelab; the Upper Stages required to place satellites in high altitude orbits; the Engineering and Technical Base support at the manned space flight centers; Payload Operations and Support Equipment for accommodating NASA payloads; Advanced Programs study and evaluation efforts; the development and first flight of the United States/Italian Tethered Satellite System; and the development of the Orbital Maneuvering Vehicle.

Spacelab is a major element of the Space Transportation System (STS) that provides a versatile, reusable laboratory which is flown to and from Earth orbit in the orbiter cargo bay. The development program which has been carried out jointly by NASA and the European Space Agency (ESA) continues with the procurement of hardware for the Hitchhiker System, the Spacelab Pallet System, the Space Technology Experiment Platform and the lay-in of spares to support the flight program.

Upper Stages are required to deploy payloads to orbits and trajectories not attainable by the Shuttle alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management activities for government and commercial Upper Stages, and a solid rocket motor integrity program to establish an engineering data base for solid stage components.

The Engineering and Technical Base provides the core capability for the engineering, scientific and technical support required at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL) for research and development activities.

The Payloads Operations and Support Equipment program develops and places into operational status the ground and flight systems necessary to support the STS payloads during pre-launch processing, on-orbit mission operations and, when appropriate, post-landing processing. Included within the program area are the STS support service for NASA payloads, satellite servicing tools and techniques development, flight demonstrations and multi-mission payloads support equipment.

The Advanced Programs effort identifies potential future space initiatives and provides technical as well as programmatic data for their definition and evaluation. Activity is focused on six major areas: advanced missions, satellite services, spacecraft systems, advanced transportation systems, crew systems, and generic space system capabilities. Advanced development activities are conducted to provide a basis for obtaining significant performance and reliability improvements and reducing future program risks and development costs through the effective use of new technology. Extensive studies are being conducted jointly with DOD on future launch vehicle requirements.

The Tethered Satellite System (TSS), a joint Italian/United States development effort, will provide a new reusable capability for conducting space experiements and unique tethered applications in regions remote from the Shuttle orbiter. The objectives of the initial TSS mission are twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn through the tether.

The development of the Orbital Maneuvering Vehicle (OMV), initiated in 1986, will provide a capability for payload delivery, retrieval, and servicing beyond the reach of the Space Shuttle or the Space Station. The first scheduled operational use of OMV is the reboost of the Hubble Space Telescope scheduled for November 1991.

Spacelab

The fiscal year 1988 Spacelab development funds are required to complete the Hitchhiker and Space Technology Experiments Platform (STEP) programs, to complete the lay-in of both U.S. and European source spares, and to make the necessary hardware and GSE modifications and upgrades for return-to-flight recertifications as recommended by the Rogers Commission in preparation for reflight in 1989.

The fiscal year 1988 operations program reflects significant restructuring and rescheduling of Spacelab missions resulting from the *Challenger* accident. Funds are required to support payload operations and to continue payload integration support, mission independent training, and logistic support in preparation for launch of the Astro-1 mission and the Materials Science Laboratory (MSL-3

and MSL-4) and two to three Hitchhiker systems in fiscal year 1989 and the first Spacelab Life Science Laboratory (SLS-1), the International Microgravity Laboratory (IML-1), MSL-5, and four Hitchhiker systems in fiscal year 1990. The support for these missions includes analytical integration, configuration management, hardware integration and software development and integration. Funding is also included to operate and maintain the SMFC and JSC Payload Operations Control Centers (POCC) required to support the Spacelab manifest. Spacelab operations also provide for replenishment spares, the operation of the depot for United States and European hardware and software, and sustaining engineering of all hardware and software.

The fiscal year 1988 request also reflects significant program restructuring and rescheduling of Spacelab missions resulting from the standdown of the Shuttle. The current program provides for launching one to two major Spacelab missions per year beginning in 1989 as compared to three to four missions planned previously.

In addition to these NASA missions, Spacelab reimbursable missions are scheduled to support DOD, Germany (D-2) and Japan (J).

Upper stages

The STS upper stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. The Inertial Upper Stage (IUS) and the commercially developed Payload Assist Modules (PAM-A, PAM-D and PAM-DII) are currently available for use on the STS. Several other upper stages now being commercially developed, including the Transfer Orbit Stage (TOS), will become available for use with the STS.

Production and operations funds in fiscal year 1988 are required to continue production of three IUS's and one PAM-S vehicle to support the Galileo, Ulysses and Magellan missions, and upper stages for the Mars Observer, ACTS, TDRSS-E and TDRSS-F missions. Monitoring of the PAM-D, PAM-DII and TOS programs will continue. Funds are also required to support continuation of the solid rocket motor integrity program. Funding starts in fiscal year 1988 on four upper stages, three PAM-D class and one Apogee and Maneuvering Stage class, for the Global Geospace Science missions.

Engineering and Technical Base

The Engineering and Technical Base (ETB) provides the core capability required to sustain an engineering and development base for various NASA programs at the manned space flight centers. Additional center program support requirements above the core level are funded by the benefitting programs, such as Shuttle Operations and Shuttle Production and Capability Development. The centers involved are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL).

The core level of support varies from center to center due to programmatic and institutional differences. At JSC, the core level requirement is that one shift of operations be maintained in the engineering and development laboratories and the White Sands Test Facility. Safety, reliability and quality assurance areas are also supported by the ETB core. The core level for the central computer

complex is established as a two-shift operation. The funding for center operations base support is split between the ETB and Shuttle Operations budget elements in accordance with the principle that ETB will provide the core level, and the benefitting program is responsible for funding additional support requirements. At KSC, due to its operational character, the core level provides for future studies and ground systems research and development. ETB funds at MSFC provide for multi-program support activities, including technical labs and facilities, reliability and quality assurance, computational and communications services, and at NSTL for facilities operations, including security.

Payload Operations and Support Equipment

The Payload Operations and Support Equipment objectives are to centralize the provisioning of payload services, both unique and common, which are required beyond the basic standard services for NASA missions, and to provide multi-mission support equipment in support of payload operations.

Payload operations funding is required to furnish continued payload services for currently scheduled NASA launches. As a result of the *Challenger* accident and the decision to cancel the Centaur program for planetary launches, there have been major changes in payload integration requirements. Major NASA payloads receiving support during this year include Hubble Space Telescope, Galileo, Ulysses, Magellan, Astro, the Advanced Communications Technology Satellite, and Tracking and Data Relay Satellite (TDRS). The change to IUS upper stages for the planetary launches of Galileo, Ulysses and Magellan requires substantial new integration. The significant change in launch dates for all NASA payloads will require a thorough reassessment of the payload integration into the Shuttle. Efforts will continue to provide the means to maintain and repair satellites on-orbit by developing a series of tools, aids, and techniques, and to demonstrate capabilities and methods of improving the efficiency of on-orbit operations. These demonstrations will provide the experience necessary for realization of the Shuttle's potential for satellite servicing missions and on-orbit assembly functions.

Advanced Programs

Advanced Program's principal objectives are to conduct mission requirements analyses, conceptual system definition, detailed system definition, and advanced and supporting developments to acquire the technical and programmatic data for the evaluation of new space flight initiatives. Future space program and systems requirements, configurations, costs, and capabilities are identified to provide the basis for development decisions on new space flight systems.

The objective of efforts to be initiated in the advanced manned mission area will be the planning and analysis of potential follow-on programs to exploit the STS and the Space Station. Integrated program options involving low Earth orbit, geostationary orbit, lunar and planetary missions will be investigated, with the multi-year purpose to develop goals, planning information, and infrastructure requirements.

In fiscal year 1988, major emphasis will be placed on system concept definition and key advanced technology in crew systems, geostationary Earth orbital unmanned platforms, reusable orbital transfer vehicles (OTVs), new capability mission kits for orbital maneuvering vehicles, future tethered systems applications, satellite servicing systems near and remote from the orbiter, and second generation shuttles. A major goal continues to be the conceptual definition of the systems architecture and space elements needed for space operations over the next twenty years.

Tethered Satellite System

The development of a Tethered Satellite System (TSS) will provide a new reusable facility for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the orbiter.

The United States is responsible for overall program management, overall systems engineering and integration, Orbiter integration, ground and flight operations, and development of the deployment mechanism. The U.S. effort was initiated in 1984. The Italians are responsible for the design and development of the satellite and the European instruments being flown on the joint missions. They initiated their development efforts in 1984.

Orbital Maneuvering Vehicle

The Orbital Maneuvering Vehicle (OMV) will provide a new STS reusable extension capability for conducting orbital operations with spacecraft and payloads beyond the practical operational accessibility limits of the baseline STS. By means of direct man-in-the-loop control, the spacebaseable reusable OMV, operating as far as 1,200 nautical miles altitude above the orbiter, will provide delivery, maneuvering, and retrieval of satellite payloads to and from altitudes or inclinations beyond the existing STS capability; reboost of satellite to original operational altitudes or higher; delivery of multiple payloads to different orbital altitudes and inclinations in a single flight; and safe deorbit of satellites which have completed their useful life. It will be designed to serve the Space Station as well and to accommodate the add-on of future "mission kits" as needed to support more advanced missions such as the servicing of satellites and platforms and the retrieval of space debris which could represent an orbital hazard to all future space missions. TRW was competitively selected and is now under contract to develop the OMB. The planned first flight for the OMV is late 1991.

Space Transportation Capability Development—Committee Comments

The Committee's authorization of $592.6 million for Space Transportation Capability Development is $24 million more than the President's budget request. This additional authorization represents an increase of $22 million for Upper Stages and $2 million for Payloads Operations and Support Equipment to procure and integrate a TOS upper stage for the Advanced Communications Technology Satellite which is scheduled to be launched in November 1990.

The Committee maintains its concern about the significant reduction in the space shuttle manifest of Spacelab missions—from twenty-eight missions through 1990 in the pre-*Challenger* manifest to eleven in the October 1986 manifest through 1994. Spacelab missions offer a unique laboratory environment for research and development activities and are important precursors to the space station. The Committee expects to be kept well-informed of any developments in this area and be apprised of any options that may be considered to compensate for any reductions in Spacelab capabilities.

Along this same line of concern, the Committee is intrigued by two concepts that could significantly enhance our Nation's short-term space capabilities and improve the prospects for our mid- and long-term policy goals. These two concepts are the Extended Duration Orbiter and the Industrial Space Facility (ISF); both of which are currently being analyzed for development by commercial entities.

The Committee wants to be sure that the United States is well prepared to take advantage of the unique opportunities which our Space Station will provide. Accordingly, the Committee favors interim measures to maintain a vigorous space science program and to obtain important flight experience that can contribute to the eventual success of the Space Station. For example, the Committee notes the recommendation from the Task Force on Scientific Uses of Space Station that "the use of free-flying, man-tended modules such as the Industrial Space Facility proposed for development by Space Industries, Inc. can provide an important, interim solution to having significant space research capabilities prior to Space Station operations."

The Committee also believes that the availability of a facility like the ISF could provide valuable flight experience prior to the construction and operation of the Space Station. The Committee urges NASA to consider and submit by November 1, 1987 a report on the ways in which such a facility could enhance U.S. space science and space station programs.

The Committee also would like NASA to reconsider the feasibility of extending the flight duration and capabilities of the orbiter. The Committee realizes the Extended Duration Orbiter (EDO) concept is not new; it has been intermittently studied by NASA since 1977. However, the events of January 1986 have significantly changed the results of prior evaluations that assumed robust shuttle flight rates (24 flights per year). The current reduction of the space shuttle flight rate has seriously reduced space science flight opportunities, and perhaps the time has come to shift the emphasis of the space shuttle program from flight rate to stay time. At the same time, the EDO, once perceived as a threat to the requirement for a permanently manned space station, now is seen as a potential aid in space station assembly and in reducing space shuttle support requirements.

The Committee, therefore, directs NASA to reassess the concept of an Extended Duration Orbiter and to report back by November 1, 1987 as to the feasibility, value, and cost of such a project. The Committee also directs NASA to assess and report back as to the

feasibility of a commercial EDO venture along the lines of the proposal submitted by EFFORT, Inc.

Finally, the Committee requests that it be kept well-informed of the progress being made in (1) the Orbital Maneuvering Vehicle program and its availability to reboost the Hubble Space Telescope in 1991 and (2) the procurement and integration of upper stages for the three planetary programs—Galileo, Ulysses, and Magellan.

In the aftermath of the *Challenger* tragedy, there is renewed interest in the value and importance of the activities in the Space Transportation Capability Development Account. The Committee strongly supports these activities and believes they can greatly enhance the overall performance and capability of the civil space program.

C. Space Sciences—$973,700,000

The Committee authorizes $973,700,000 for Space Sciences—Physics and Astronomy, Life Sciences and Planetary Exploration—for fiscal year 1988. This is $24.7 million greater than the President's fiscal year 1988 budget request in order to accommodate more robust Explorer and suborbital programs. Of this amount, $591,800,000 is for Physics and Astronomy, $74,600,000 is for Life Sciences, and $307,300,000 is for Planetary Exploration.

1. PHYSICS AND ASTRONOMY—$591,800,000

Summary of fiscal year 1988 funding for physics and astronomy

Hubble Space Telescope	$98,400,660
Gamma Ray Observatory	49,100,000
Spacelab/Space Station payload development	95,400,000
Explorer development	80,300,000
Mission operation and data analysis	128,100,000
Research and analysis	60,100,00
Suborbital program	80,400,000
Total for physics and astronomy	591,800,000

The objectives of the Physics and Astronomy program are to increase understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of stars and planets. The objects under study include the most distant clusters and galaxies, stars and structures in nearby galaxies, and the interstellar medium in our galaxy. The most unusual and exotic phenomena exhibited as quasars, black holes, neutron stars, and pulsars are of particular interest. We also include our own Sun, with its multitude of time varying phenomena at all scales of special resolution. Spece research allows observations in wavelength regions, such as the infrared, ultraviolet, or x-rays and gamma-rays, which are absorbed by the Earth's atmosphere, or in the visible region, where ground based work is limited by atmospheric distorting effects. We also couple these observations to those of cosmic ray particles, which have their origin in energetic acceleration processes occurring in sites such as solar flares and supernovae.

The objectives of the program are accomplished with a mixture of large, complex free-flying space missions, less complex Explorer spacecraft, Shuttle/Spacelab flights, retrievable Spartans, and suborbital opportunities. The latter include balloons, aircraft, and

sounding rocket flights. In the future, the Space Station will provide an opportunity for both attached payloads and major free-flying observatories requiring assembly, maintenance, and refurbishment on-orbit. The entire program rests on a solid basis of supporting research and technology, data analysis, and theory.

Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories. The scientific information obtained and the technology developed in this program are made available to the scientific communities and the general public for application to the advancement of scientific knowledge, education and technology.

Hubble Space Telescope development

The Hubble Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the board question of the origin and scale of the universe. The Hubble Space Telescope will operate in space above the atmospheric veil surrounding the Earth, increasing dramatically the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Hubble Space Telescope will permit scientists to conduct investigations that could never be carried out with ground-based observatories limited by the obscuring and distorting effects of the Earth's atmosphere.

The Hubble Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will allow the objects under study to be recorded in greater detail. It will make possible unique observations of objects so remote that the light will have taken many billions of years to reach the Earth. The Hubble Space Telescope will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as the observation of such highly evolved objects as supernova remnants and white dwarf stars. With the Hubble Space Telescope, we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy; it may also be possible to determine whether some nearby stars have planetary systems.

The Hubble Space Telescope will be an automated observatory, delivered into orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The Hubble Space Telescope design will permit on-orbit maintenance and repair, and/or retrieval by the Space Shuttle for return to Earth for required refurbishment and then relaunch by the Space Shuttle.

The FY 1988 funding level is required to maintain the irreplaceable skilled experts who have hands-on experience with the spacecraft. During fiscal year 1988, the HST Program will be performing additional safety and spacecraft review work as a consequence of the shuttle accident, as well as returning to the program manning levels needed to support pre-ship functional testing of the HST system, transporting the spacecraft to Kennedy Space Center, and conducting launch preparations and operations at KSC.

Gamma Ray Observatory development

The Gamm Ray Observatory (GRO) has as its objective the measurement of the highest energy electromagnetic radiation emitted from sources in the cosmos. This spectral region represents one of the last frontiers in astronomy to be studied at high sensitivity. Because of their extreme energy, gamma-rays are produced by the most energetic and intriguing phenomena occurring in the universe; phenomena occurring in the central energy source region of quasars, in supernovae, near black holes, and on the surface of neutron stars.

In fiscal year 1987, instrument calibration and testing will continue. Assembly of the spacecraft structure will be completed, electronic manufacturing will continue, and all government furnished property subsystems for GRO will be delivered.

Fiscal year 1988 funding is required for completion of the spacecraft modal survey and static load testing. In addition, the fabrication and testing of the spacecraft attitude control and power system electronics will be completed. The development of the GRO mission operations and data systems will be continued, and the implementation of the payload operations control center (POCC) for GRO will be completed. Funding is also required for final testing, calibration and shipment of all four science instruments to the spacecraft contractor for the beginning of spacecraft integration and testing.

Spacelab/Space Station Payload Development and Mission Management

A primary objective of the Spacelab Payload Development and Mission Management program is to develop instruments used for Shuttle/space flight investigations in the disciplines of physics and astronomy on board the Space Shuttle or Spacelab carriers. These science payloads include sounding rocket class experiments for flight on the Space Shuttle.

A second objective is to initiate the necessary planning, definition and development of payloads and missions as the Office of Space Science and Applications begins its preparations as a future major user of the Space Station complex. This new focus includes the study definition of integration and operational requirements of potential Space Station payloads and missions, in anticipation of the new, integrated methods of conducting scientific research which the Space Station will offer.

Another major objective is to manage the mission planning, integration, and execution of all NASA Spacelab and attached payloads. This includes system management and engineering development of flight support equipment and software; development of certain interface hardware; payload specialist training and support; integration of the science payloads with the Spacelab system; payload flight operations; data dissemination to experimenters; and initial analysis of flight data from physics and astronomy science payloads. Similar mission management activities will be carried out for Space Station payloads as they enter the development phase and interface requirements become well defined.

Mission management of ongoing Spacelab missions will continue in fiscal year 1988. For non-physics and astronomy missions, such as the Spacelab Life Sciences missions (SLS) and the International Microgravity Lab (IML), this includes all Spacelab efforts except instrument development and data analysis. Development of instruments will continue for the Space Plasma Lab as well as for the Shuttle High Energy Astrophysics Lab. For the Astro-1 mission, final integration and test activities will resume in preparation for a planned flight in early 1989. Fiscal year 1988 funding will support the continued development of low-cost sounding rocket class payloads which will be flown on the Space Shuttle to provide more flight opportunities for the science community.

In addition, fiscal year 1988 funding is required to continue ongoing Space Station payload development and planning activities. Fiscal year 1988 funding will support continued early definition, design and development activities for payloads selected for early Space Station flights. Other planning activities will address concerns or issues that typically cut across OSSA disciplines and will include continued science operations concept development, information systems concept and architecture studies, servicing studies, platform utilization studies as well as other special systems engineering and integration support studies.

Explorer development

Investigations selected for Explorers are usually of an exploratory or survey nature, or have focused specific objectives not requiring the capabilities of a major observatory. Past Explorers have discovered radiation trapped within the Earth's magnetic field, investigated the solar wind and its interaction with the Earth, studied upper atmosphere dynamics and chemistry, mapped our galaxy in radio waves and gamma-rays, and determined the properties of the interstellar medium through ultra-violet observations.

Recent Explorers have performed active plasma experiments on the magnetosphere, made *in-situ* measurements of the comet Giacobinni-Zinner, and completed the first high sensitivity, all sky survey in the infrared, discovering over 300,000 sources.

Solar terrestrial and atmospheric Explorers provide a means for conducting studies of the Earth's near space environment. The International Sun Earth Explorer (ISEE–1977), International Cometary Explorer (ICE–1978), Dynamics Explorer (DE–1981), and Advanced Magnetic Particle Trace Experiment (AMPTE–1984), have provided data on plasmas and fields, near the Earth and throughout the interplanetary medium.

Astrophysics Explorers have been the principal means for conducting the first sky surveys in the gamma ray, x-ray, ultraviolet, infrared, and low frequency radio regions of the electromagnetic spectrum. The IUE (1978) is still operating and has shown that our galaxy has an extended hot halo, that the local interstellar medium is much more transparent and less homogeneous than expected, and determined the spectra of hundreds of hot stars which are losing mass. The IRAS (1983), in nearly a year of operation, performed a complete sky survey over the 10–100 micron region, locating over 300,000 sources.

In fiscal year 1986, a new cooperative mission called Solar-A (formerly High Energy Solar Mission, HESP) was initiated with the Japanese. Solar-A will be launched in 1991 to study the Sun during the upcoming solar maximum. The U.S. has selected an instrument for this spacecraft which will relate energetic solar phenomena and dynamic coronal structures seen in hard and soft x-rays to the topology of evolving solar magnetic fields. This will be the first simultaneous observations of these phenomena from space.

In fiscal year 1987, development continues on the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EUVE), and on the x-ray imaging instrument to be flown on the German Roentgen Satellite (ROSAT). COBE will carry out a definitive, all-sky exploration of the infrared background radiation of the universe between the wavelengths of a micrometer and 9.6 millimeters. Funding in fiscal year 1987 will be used to continue development and testing of the three COBE instruments and to redesign the COBE spacecraft to fit on the Delta vehicle.

ROSAT, a cooperative project between the Federal Republic of Germany (FRG) and the United States will perform a high resolution imaging survey of the x-ray sky and provide in-depth studies on selected objects. The United States will provide one of the ROSAT instruments and the launch services; Germany will provide the spacecraft, telescope, and other instruments. Although ROSAT is currently manifested for a 1994 Shuttle launch, a possible launch on an expendable launch vehicle in late 1989 or early 1990 is also under consideration.

Definition and design will continue in fiscal year 1987 on the X-ray Timing Explorer. This mission, the last currently planned major effort in the Explorer line, can be ready for launch as early as 1993. During fiscal year 1986, a "Dear Colleague" letter was issued to obtain proposals for future Explorers. Over 43 were received, and these will be evaluated in fiscal year 1987, but selection for further study will depend on the availability of future launch opportunities for the Explorer program.

During fiscal year 1988, the reconstruction, integration and test of the COBE spacecraft structure and its instruments will be completed, and the spacecraft will begin pre-launch preparations. The major activity will be on the EUVE development. Activities on ROSAT and the development of the U.S. instrument for the Japanese Solar-A will also continue.

Mission operations and data analysis

The purpose of the mission operations and data analysis effort is to conduct operations and analyze data received from physics and astronomy spacecraft after launch. The program also supports the operation of a number of spacecraft after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including control centers and related data reduction and engineering supported activities, are

typically carried out under a variety of mission support or center support contracts.

The fiscal year 1988 funding level is required to maintain critical skills for the operation and maintenance of the Hubble Space Telescope and to prepare for launch activities currently scheduled for the first quarter of fiscal year 1989.

Mission operations, data analysis, and guest investigator programs will continue for the Solar Maximum Mission (SMM) and the International Ultraviolet Explorer (IUE). Funding will also continue for the High Energy Astronomical Observatories (HEAO 1-3), and the Infrared Astronomy Satellite (IRAS) data analysis. These programs have produced valuable data sets which are used by a wide segment of the astronomy community.

Research and analysis

This program provides for the preliminary studies required to define missions and/or payload requirements, as well as providing a research and technology base necessary to define, plan and support flight projects.

The supporting research and technology (SR&T) funding will provide for continuation of definition work on Gravity Probe-B. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments will also be continued. Results achieved in the SR&T program will have a direct bearing on future flight programs. For example, the development of advanced x-ray, ultraviolet, and infrared astronomy imaging devices under this program may enable spacecraft to carry instruments for astronomical observations which have increased orders of magnitude in sensitivity and improved resolution over currently available detectors.

The SR&T program carries out its objectives through universities, nonprofit and industrial research institutions, NASA centers and other government agencies. Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

Candidate missions for the 1980s and early 1990s that require advanced technology development activities include the Advanced X-Ray Astrophysics Facility (AXAF) and the Space Infrared Telescope Facility (SIRTF). The AXAF mission, which is the first priority new mission recommendation in astronomy by the National Academy of Sciences, will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology.

During fiscal year 1988, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Fiscal year 1988 funding will also support continued studies on potential candidate missions such as the Advanced X-Ray Astrophysics Facility and the Space Infrared Telescope Facility. In the data analysis activities to be carried out at university and government research centers in fiscal year 1988, emphasis will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft and ground observatories). The Gravity Probe-B activities in fiscal year 1988 are designed to verify the entire GP-B design, leading to confidence in

the information necessary to decide the feasibility of progressing into the next phase of design and development activities.

Suborbital programs

The suborbital program uses balloons, aircraft, and sounding rockets to conduct versatile, relatively low-cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and on an international cooperative basis.

A major objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters.

Forty-four sounding rockets are currently scheduled for launch in fiscal year 1987. Included in this number are eight NASA launches in Greenland as a follow-up to the fiscal year 1985 effort. Of significant interest in fiscal year 1986 were two rocket launches to observe Halley's Comet which were recovered, field refurbished, and reflown for a total of four flights. These flights produced some of the data originally planned to be obtained from the Astro-1 Shuttle flight which was postponed as a result of the 51-L accident. An equivalent number of flights is scheduled for fiscal year 1988.

Research with instrumented jet aircraft has been an integral part of the NASA physics and astronomy program since 1965. For astronomy research, the airborne science and applications program operates the "Kuiper Airborne Observatory." This full-scale manned facility consists of a C-141 equipped with a 91-centimeter infrared telescope. The C-141 aircraft, able to fly for several hours at altitudes approaching 13 kilometers, provides a cloud-free site for astronomical observations.

The Airborne Science and Applications program also operates an ER-2, two U-2Cs, and a C-130. In addition, an aircraft has been acquired to replace the CV-990 research facility, "Galileo II," which was destroyed in 1985. The replacement, A DC-8, is undergoing modifications and is expected to be ready for science operations in late 1987. Acquisition of a second ER-2, to replace the aging U-2Cs is under way. These aircraft support other major segments of the Space Science and Applications programs dealing with the Earth, the oceans, and the atmosphere.

The Balloon Program a cost-effective means to test flight instrumentation in the space radiation environment and for making observations at altitudes which are above most of the water vapor in the atmosphere. Balloon experimentation is particularly useful when studying infrared, gamma-ray, and cosmic-ray astronomy. In many instances it is necessary, because of size, weight, cost, or lack of other opportunities, to fly primary scientific experiments on balloons.

The balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery, as well as for maintenance and operations of the National Scientific Balloon Facility (NSBF) at Palestine, Texas.

The Spartan missions involve low-cost Shuttle payloads flown as autonomous sub-satellites which are deployed and retrieved by the Space Shuttle. Six Spartan missions are currently under development, each with a different scientific instrument.

Fiscal year 1988 funds will provide for continuation of the sounding rocket, Spartan, and balloon programs including management and operation of the NSBF. This funding is also required to continue definition activities for balloon improvement and for potential long-duration balloon flights. In fiscal year 1988, the Airborne Science and Applications funding will be used to continue flights of the Kuiper Airborne Observatory. Requested fiscal year 1988 funding will allow operation of the DC-8, the ER-2s, and the C-130. Operation of these aircraft will allow continuation af airborne infrared astronomy exploration, collection and analysis of stratospheric air samples, testing of newly developed instrumentation, and the demonstration of new sensor concepts.

Physics and Astronomy—Committee Comments

The Committee authorizes $591.8 million for Physics and Astronomy in fiscal year 1988. This increase of $24.7 million, compared to the President's budget request, is to augment Explorer Development (+$20 million) and the Suborbital Program (+$4.7 million).

The events of the last year have not done much to improve the status of NASA's Physics and Astronomy Programs. The Hubble Space Telescope (HST) and the Gamma Ray Observatory (GRO) are still grounded and based on the October 1986 Shuttle manifest, are not scheduled for launch until November 1988 and January 1990, respectively, and the Spartan program is being redesignated and rescoped. Meanwhile, the next great observatory scheduled to attain new start status, the Advanced X-Ray Astrophysics Facility (AXAF), was not included in the President's fiscal year 1988 budget request nor was the High Resolution Solar Optical Telescope, which is the only new start space science program directly associated with the space station program.

As can be seen in the following table, the space shuttle *Challenger* tragedy has adversely affected the Physics and Astronomy payload launch schedule.

PHYSICS AND ASTRONOMY PAYLOAD LAUNCH DELAYS [1]

Payload	Preaccident launch date	Current launch date	Delay (in months)
Astro-1	Mar. 6, 1986	Jan. 19, 1989	34
Hubble Space Telescope	October 1986	Nov. 17, 1988	25
Environmental observation mission	Oct. 27, 1986	Unscheduled	
Astro-2	Jan. 12, 1987	do	
Shuttle High Energy Astro Physics Laboratory	do	4th quarter 1993	82
Spartan-2	Jan. 27, 1987	2d quarter 1991	52
Space Life Sciences Laboratory	Mar. 16, 1987	Dec. 7, 1988	33
Spartan-3	Aug. 4, 1987	2d quarter 1992	57
Astro-3	Aug. 18, 1987	Unscheduled	
Rosat	Sept. 28, 1987	1st quarter 1994	77
Spartan-205	Nov. 9, 1987	Unscheduled	

PHYSICS AND ASTRONOMY PAYLOAD LAUNCH DELAYS [1]—Continued

Payload	Preaccident launch date	Current launch date	Delay (in months)
Gamma Ray Observatory	June 8, 1988	Jan. 18, 1990	19
Spartan 211	June 14, 1988	Unscheduled	
Cosmic background explorer	July 15, 1988	do	

[1] Astronomy and physics payloads were slow to have flown on some of the 10 materials science labs listed on the November 1985 manifest.

Source: National Aeronautics and Space Administration, Space Transportation System, Space Shuttle Payload Flight Assignments, November 1985 and October 1986.

In light of these serious problems, the Committee has taken three steps that it hopes will correct some of these deficiencies in a cost effective manner.

First, it has augmented the Explorer Program by $20 million to promote additional low cost, high return space science missions. These funds should permit NASA to initiate evaluation of the 43 pending proposals and to start development of additional space science missions.

Second, the Committee has increased funding for the Suborbital program by $4.7 million to provide additional flight opportunities for space scientists and graduate researchers. The Committee is deeply committed to our university space science programs and is hopeful these augmentations will assist these programs during the space shuttle hiatus.

Finally, the Committee has initiated a new line item in the NASA Space Flight, Control and Data Communications appropriations account entitled "Expendable Launch Vehicle (ELV) Operations." This new entry is to initiate procurement of ELVs, pursuant to a NASA/DOD quid pro quo or launch services agreements with commercial vendors, to launch NASA payloads. The Committee feels this initiative should greatly assist the Physics and Astonomy Program which has several candidates for ELVs.

Despite these actions, the Committee remains concerned about the overall health and well-being of the space science community. The number of prestigious institutions and advisory committees issuing reports about the crisis in space science is troublesome to the Committee. The Committee, therefore, intends to hold hearings this Summer and Fall on the long-term policy goals and budgetary requirements of NASA and the ability of NASA to balance its research and development mission with its operational programs.

Meanwhile, the Committee expects to be kept well informed of any technical concerns, schedule changes, or additional cost requirements for the Hubble Space Telescope or Gamma Ray Observatory Programs and to be well advised by the Physics and Astronomy Program Office of developments in the space station program that impact this area of space science.

The Committee also expects NASA to down-select to one contractor for the Advanced X-Ray Astrophysics Facility in fiscal year 1988 in order to better position the program for Phase C/D development activities and to take advantage of any potential economies.

In recognition of the severe strain the current "standdown" period has inflicted on the space science community, the Committee has fully authorized NASA's fiscal year 1988 Physics and Astronomy research and analysis and mission operations and data

analysis budget requests. The Committee notes the importance of the university space research programs to our national space infrastructure and believes that these university space research programs should continue to perform productive and meaningful research during this period.

2. LIFE SCIENCES—$74,600,000

The Committee authorizes $74,600,000 for Life Sciences in fiscal year 1988. This is the same as the President's budget request.

Summary of fiscal year 1988 funding for life sciences

Life sciences flight experiments	$32,900,000
Research and analysis	41,700,000
Total for life sciences	74,600,000

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight and to advance the understanding of the basic mechanisms of biological process by using the unique capabilities of the space program. Results from the research program are applied to: the immediate needs in the maintenance and health of the astronauts; understanding biological mechanism and the response of biological systems to weightlessness; the design of the advanced life support systems for use on future missions; and understanding the biosphere of the planet Earth, as well as the origin, evolution, and distribution of life in the universe.

The Life Sciences program is the key to developing a capability to sustain a permanent manned presence in space and to utilize the space environment to study living systems. These activities include both ground-based and space research efforts which are mutually supportive and integrated, and use a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

The Life Sciences research and analysis program includes five major elements; (1) space medicine; (2) advanced life support systems; (3) gravitational biology; (4) exobiology research; and (5) biospheric research.

The goals of the Space Medicine program are to assure space crew members' health and ability to function effectively in the space environment.

The Advanced Life Support System program seeks ways to develop technologies for more efficient life support systems for the space program.

The goals of the Gravitational Biology program are to further our understanding of basic physiological mechanisms and the effects of microgravity on plants and animals through the use of the space environment.

The Exobiology efforts are concentrated on studies of life's origin, with particular emphasis on developing sounds hypotheses which could lead to discovering the relationships which may link the formation of the solar system and the origin of life.

The Biospherics Research Program seeks to utilize NASA technology in remote sensing, combined with ground-based research

and mathematical modeling, to study the biosphere (the thin layer around the planet that contains all of terrestrial life).

Life Sciences Flight Experiments

The objective of the life Sciences Flight Experiments program is to assimilate information and scientific questions from the various life sciences disciplines and translate them into payloads designed to expand the understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, defintion, inflight execution, data analysis, and reporting on medical and biological investigations involving humans, animals and plants. Past experience indicates that humans clearly undergo physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth; however, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond several months, these chagnes may prove irreversible. Shuttle/Spacelab missions are suitable for gaining a greater understanding of the early response to weightlessness, which will improve the management of several existing problems (e.g., space adaptation syndrome) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure (e.g. Space Station).

Fiscal year 1988 funding is required for the final preparation and flight of approved experiments and the continued definition and development of new experiments and hardware that will be flown on future Spacelab/Shuttle missions—i.e., Shuttle middecks, Japanese–J mission, the second dedicated life sciences mission (SLS–2), German D–2 mission, IML–2, and SLS–3. The selection of new experiments through the Announcement of Opportunity (AO) process is continuing. In addition, increasing activities are planned to support the development of Space Station Life Sciences experiments.

Research and analysis

The research and analysis activity of the Life Sciences program is concerned with ground-base and pre-flight research in basic biology and in those medical problem areas that affect manned spaceflight.

In fiscal year 1988, the Space Medicine program will collect information on occupational exposure in zero-gravity on each Shuttle flight and conduct inflight clinical testing of countermeasures, especially in the areas of cardiovascular deconditioning, vestibular problems and muscle atrophy. The program will also develop health care procedures, equipment, and facilities compatible with the space environment. At the same time, problems associated with the initial adaptation to weightlessness, such as vestibular dysfunction and fluid shifts, will continue to be vigorously investigated. Furthermore, increased emphasis will be placed on radiation biology so that it will be possible to precisely measure dosages and effects of cosmic and solar radiation. This information will be required to determine the proper radiation shielding of humans in space. The performance and efficiency of flight crews will be emphasized by research in psychology and human factors.

Life Sciences—Committee Comments

The Committee authorizes $74.6 million, the President's budget request, for Life Sciences for fiscal year 1988.

The Committee continues to maintain its belief that the level of support for the NASA Life Sciences Programs is not commensurate with our Nation's desire to establish a permanent presence in space and to pursue long duration missions to other planetary bodies.

As the space station program progresses and leadership initiatives are evaluated, it is essential that the Life Sciences program assume a higher priority. The Committee, therefore, expects to see increased support of these activities in future budget submissions.

3. PLANETARY EXPLORATION—$307,300,000

The Committee authorizes $307,300,000 for planetary Exploration in fiscal year 1988. This is the same as the President's budget request.

Summary of fiscal year 1988 funding for planetary exploration

Galileo development	$55,300,000
Magellan	59,600,000
Ulysses	10,800,000
Mars observer	29,300,000
Mission operations and data analysis	77,000,000
Research and analysis	75,300,000
Total planetary exploration	307,300,000

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteriods, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means of understanding the origin and evolution of the solar system; (2) to understand the Earth better through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis of the Earth-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these bodies start at the level of reconnaissance to achieve a fundamental charcterization of the bodies and then proceed to levels of more detailed study.

Both the Galileo orbiter/probe mission to Jupiter and the Ulysses mission to the Sun had been ready for launch in May 1986 on the Space Shuttle/Centaur Upper Stage. The *Challenger* accident in January 1986 forced a postponement of these launches, and subsequent cancellation of the Centaur launch stage resulted in further re-evaluations of these missions. The Magellan mission was also adjusted to accommodate a one-year launch delay caused by the *Challenger* accident and cancellation of the original Centaur upper stage.

According to a plan recently agreed to by NASA and ESA, Galileo will be launched in October 1989, and Ulysses will be launched in October 1990. Despite the fact Ulysses will be launched one year after Galileo, it will arrive at its destined location in 1984, one year before Galileo enters the Jovian system.

Magellan, formerly the Venus Radar Mapper mission, will provide global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Magellan now is scheduled for launch in April 1989 from the Shuttle with an IUS.

Mars Observer will follow up on earlier discoveries of Mariner 9, and Viking and will be launched on the Shuttle in 1992.

Beginning in later 1985, we entered an exciting new phase of exploration by making our first close-up studies of the solar system's mysterious small bodies—comets and asteroids. These objects may represent unaltered original solar system material, preserved from the geological and chemical changes that have taken place in even small planetary bodies. By sampling and studying comets and asteroids, we can begin to make vigorous inquiries into the origin of the solar system itself.

The Planetary Exploration program is also founded on a coordinated research and analysis effort. Research and analysis activities will continue to maximize the scientific return from both ongoing and future missions and from such Earth-based activities as lunar sample and meteorite analysis, telescope observations, theoretical and laboratory studies, and instrument definition. This program strives for interdisciplinary coordination among various research groups and for the wide dissemination of scientific results. A close coupling is also maintained between the research programs and planning activities that are undertaken to define the scientific rationale and technology needed for future missions.

Galileo development

The objective of the Galileo program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere, and satellites through the use of both remote sensing by an orbiter and *in situ* measurements by an atmospheric probe. The scientific objectives of the mission are based on recommendations by the National Academy of Sciences to provide continuity, balance, and orderly progression of the exploration of the solar system.

Current plans call for the orbiter and probe to be launched together in the time frame as a single combined payload using a Shuttle/Inertial Upper Stage (IUS) combination on an initial trajectory toward Venus, followed by two Earth swingbys. The three gravitational assists will provide the energy required for a trajectory to Jupiter. When the orbiter arrives at Jupiter in 1995, it will provide remote sensing of the proble entry site and provide the link for relaying the probe data back to Earth. Twenty-two months of orbital operations will follow during which both Jupiter's surface and the dynamic magnetosphere will be comprehensively mapped. During this time, ten close flybys of Jupiter's major satellites are targeted.

The Galileo flight system will be powered by two general purpose heat-source Radioisotope Thermoelectric Generators (RTG) developed by the Department of Energy. The orbiter will carry approxi-

mately 100 kg of scientific instruments, and the probe will carry approximately 25 kg of scientific instruments.

Fiscal year 1988 funds will provide for completion of the reassembly, integration and initial testing of the reintegrated spacecraft system. Modification of the flight software and mission operations system will be continued.

Magellan

The objective of the Magellan mission is to address fundamental questions regarding the origin and evolution of Venus through global radar imagery of the planet. Magellan will also obtain altimetry and gravity data to accurately determine the planet's gravity field as well as internal stresses and density variations. The detailed surface morphology of Venus will be analyzed to compare the evolutionary history of Venus with that of the Earth.

The Magellan spacecraft will carry a single major scientific instrument, a synthetic aperture radar, which will be used to obtain high resolution (120 to 200 meter) images of the planetary surface as well as altimetric data. Gravity data will be obtained by processing radio signals from the spacecraft. Spacecraft development is making extensive use of existing designs, technology, and residual hardware; for example, the spacecraft will use an existing spacecraft structure, large antenna, and propulsion components from the Voyager program.

In April 1989, the Magellan spacecraft will be launched by the Shuttle/Inertial Upper Stage (IUS) on a direct trajectory to Venus. Arriving at Venus in July 1990, the spacecraft will perform a retropropulsive maneuver and enter a near-polar elliptical orbit. After an initial check-out period, the spacecraft will map a major portion of the planet over a 243-day period (one Venus year) with a ground resolution of about 150 meters.

In fiscal year 1988, the flight model of the radar instrument will be delivered for integration with the spacecraft and environmental testing will be initiated for the entire system. Integration of the mission operations system will be completed to be followed by initiation of operations testing and training preparatory for launch.

Ulysses

Ulysses is a joint mission of NASA and the European Space Agency (ESA). ESA is providing the spacecraft and some scientific instrumentation. The U.S. is providing the remaining scientific instrumentation, the launch, tracking support, and the Radioisotope Thermoelectric Generator (RTG). The mission is designed to obtain the first view of the Sun above and below the plane in which the planets orbit the Sun. The mission will study the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, to provide a better understanding of solar activity on the Earth's weather and climate.

Because of the *Challenger* accident and subsequent cancellation of the Centaur upper stage, the Ulysses launch is currently planned for October 1990.

Fiscal year 1988 funding will provide for completion of the documentation of the new spacecraft/launch vehicle interface, launch

approval activities involving the RTG, and support for retesting the spacecraft and the science instruments.

Mars Observer missions

The Mars Observer mission is the first in a series of planetary missions utilizing a new low-cost approach to inner solar system mission exploration. This approach, which was recommended by NASA's Solar System Exploration Committee, starts with a well-defined and focused science objective and makes use of high-inheritance, modified production-line Earth-orbital spacecraft. The objective of the Mars Observer mission is to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, figure, gravity and magnetic fields of Mars to determine the location of volatile reservoirs and characterize their interaction with the Martian environment.

The limitation on the number of launch opportunities through 1990 and the further restrictions placed on scheduling by the timing requirements for planetary launches have necessitated delaying the planned launch of Mars Observer from 1990 until the following planetary opportunity 25 months later. The current plan is to launch the mission in 1992 using the Space Shuttle with a Transfer Orbit Stage (TOS). The spacecraft will be inserted into a near-polar Martian orbit in 1993, from which it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of a full Martian year, which is about two Earth-years.

The fiscal year 1988 funding required to initiate instrument hardware fabrication and assembly and to maintain a minimum level of support in spacecraft and ground operations subsystem developments.

Mission operations and data analysis

The objectives of the mission operations and data analysis activities are in-flight operation of planetary spacecraft and the analysis of data from these missions. Currently, two major classes of planetary spacecraft are operating—the Pioneer and the Voyager spacecraft. The planetary flight support activities are those associated with the design and development of planetary flight operation systems, and other activities that support the mission control, tracking, telemetery, and command functions for all planetary spacecraft.

The two Voyager spacecraft are now traveling through the outer solar system on trajectories that will take them into interstellar space. Voyager 1 continued to provide data on the interplanetary medium in that distant part of the solar system. In January 1986, Voyager 2 made a close flyby of the planet Uranus, the first time this planet has ever been visited by a spacecraft. The observatory phase of this encounter, which began in November 1985, included detailed observations of the planet, its rings, and moons. Upon completion of the Uranus encounter, the spacecraft began its path to the planet Neptune, where, in 1989, it will provide us with our first close look at this distant planet.

Pioneers 10 and 11 will continue to explore the outmost solar system. Pioneer 10 will soon enter the unexplored region beyond Pluto where the Sun's influence is secondary to those of true interstellar space. These spacecraft will continue the search for gravitational evidence of a tenth planet. Pioneers 6–9 are still collecting information on the interplanetary magnetic field and solar wind as they orbit the Sun.

The planetary flight support activities include the procurement, operation and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory (JPL). In addition, the activity supports the development of the Space Flight Operations Center (SFOC) at JPL. This facility will be a versatile, cost-effective means for carrying out multimission data acquisition, telemetry, image processing, and for commanding of planetary and orbital spacecraft.

Fiscal year funding is required for the continued operation and data analysis activities in support of the Voyager and Pioneer missions. Development activities will also be continued in fiscal year 1988 on the Space Flight Operations Center (SFOC) at the Jet Propulsion Laboratory.

Research and analysis

The research and analysis program consists of four elements required to: (1) assure that data and samples returned from flight missions are fully exploited; (2) undertake complementary laboratory and theoretical efforts; (3) define science rational and develop required technology to undertake future planetary missions; and (4) coordinate an International Halley's Comet Watch and provide coinvestigator support to the European Space Agency's Giotto mission to Halley's Comet.

The supporting research and technology activity includes planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, and instrument definition.

The objective of the advanced program activity is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; the technological and fiscal feasibility is evaluated, and the scientific merit is determined through interaction with the scientific community. The strategy for future solar system explorations has been developed by the Solar System Exploration Committee (SSEC), and advisory group, which has recommended a comprehensive program of missions to the inner and outer solar system.

The Mars Data Analysis activity continues to ensure that we capitalize on the wealth of data provided by Viking and earlier missions and that we are scientifically prepared for the next phase of Mars exploration. While continuing to support a variety of scientific investigations, the major emphasis of this program will address the origin and evolution of Martian volatiles.

The International Halley's Comet Co-Investigations and Watch program is part of an international program of cooperative astronomical observations of Halley's Comet. During 1986, support was

provided to nearly three dozen U.S. co-investigators on the European Space Agency's (ESA) Giotto mission and to conducting complementary remote sensing investigations carried out with ground based telescopes, aircraft, rockets, and distant spacecraft. Concurrently, an observation program called the International Halley Watch, coordinated by the United States, conducted world-wide scientific observations of the Comet Halley. The objectives of the Watch are: (1) to coordinate scientific observations of Comet Halley through its 1985–86 apparition; (2) to promote the use of standardized instrumentation and observing techniques; (3) to help insure that data are properly documented and archived; and (4) to receive and distribute data to participating scientists.

The fiscal year 1988 Halley's Comet Co-Investigations and Watch funding is required to continue support of U.S. co-investigators involved in the European Space Agency's Giotto mission who will be analyzing and archiving the data acquired during the encounter with Halley's Comet. International Halley Watch funding will support the archiving and distribution of ground-based observations.

The fiscal year 1988 funding is also required to continue operations of both the Infrared Telescope Facility and the Lunar Curatorial Facility.

Planetary Exploration—Committee Comments

The Committee authorizes $307.3 million for Planetary Exploration for fiscal year 1988, the President's budget request, but the Committee is concerned that there will be additional requirements in fiscal year 1988 as a result of the significant launch delays in the Planetary Exploration Program. The Committee feels that the currently manifested planetary missions are of the highest priority and should be treated accordingly in order to minimize the degree of post-*Challenger* stress in the science community.

As noted in "The Crisis in Space and Earth Science",

> Even before the *Challenger* accident, and the resulting hiatus in the space program, it was becoming clear that the nature of the Space and Earth Science Program was changing and that major stresses were developiong as a result of those changes. Within the scientific community there was growing sense of unease and frustration over the program's diminishing pace. As the result of a number of trends, it appeared that a major transition as taking place in the nature of the Space and Earth Science Program, but it seemed that this transition was occurring more by accident than as a matter of conscious policy. Decisions were being made that had long-term consequences on ways the program would be conducted, but the consequences of those decisions were largely unexamined. More and more missions were being identified as candidates for "New Starts" at a time when prospects for New Starts were becoming uncertain. . . .

In the post-*Challenger* environment, the situation has worsened. As highlighted by the following table included in the recent Congressional Budget Office report entitled, "The 1988 Budget and the

Future of NASA," major space science payloads manifested to fly on the space shuttle have been significantly delayed. and these delays also have significantly added to the projected costs of these missions.

PLANETARY MISSION LAUNCH DELAYS

Mission	Preaccident launch date	Current launch date	Delay (in months)
Ulysses	May 15, 1986	Oct 5, 1990	53
Galileo	May 20, 1986	Nov. 1, 1989	41
Magellan (Venus radar mapper)	Apr. 6, 1988	Apr. 25, 1989	13
Mars observer	August 1990	4th quarter 1992	27

Source: National Aeronautics and Space Administration, Space Transportation System, Space Shuttle Payload Flight Assignments, November 1985 and October 1986

Besides further squeezing out any potential "new starts," these delays have adversely affected the scientific teams and the scientific community. Worse yet, 33 space science missions on the pre-*Challenger* space shuttle manifest have been completely off-loaded with no designation of an alternative launch vehicle.

It is in this predicament that the Committee discovers NASA's space science programs, and it is this predicament that the Committee must attempt to ameliorate. Therefore, the Committee has exempted the entire space science and space applications portion of the budget from any reductions and in some cases has been able to add funds.

Despite these setbacks, the Committee's commitment to a robust space science program, including planetary exploration, is as strong as ever, as is its resolve to provide expendable launch vehicles to help fly these critical space science missions.

The Committee is pleased that after months of negotiations, the U.S. and the European Space Agency (ESA) have finally agreed on the launch of Galileo Mission in October 1989, and the launch of Ulysses Mission in October 1990. These two planetary missions, originally scheduled to be launched in May 1986, are critical elements of the restoration of the U.S. planetary program.

The Committee also is hopeful the Magellan Mission, formerly the Venus Radar Mapper Program, will remain on schedule and be launched on the space shuttle in April 1989 (Magellan will be the first U.S. planetary mission since the Voyager was launched in 1978). The Committee is concerned that there will be additional fiscal year 1988 budget requirements for the Magellan Mission. The Committee expects to be notified immediately if such requirements surface so that they can be addressed expeditiously and effectively.

As for the Mars Observer Mission, the Committee has thoroughly reviewed the 1990 and 1992 launch options and has decided to budget for a 1992 launch date. While there are many factors in favor of a 1990 date, the Committee is reluctant to try and force a 1990 launch and feels that a 1992 mission presents fewer risks and fewer schedule pressures.

In recognition of the severe strain the current "standdown" period has inflicted on the space science community, the Committee has fully authorized NASA's fiscal year 1988 Planetary Exploration research and analysis and mission operations and data anal-

ysis budget requests. The Committee notes the importance of the university space research programs to our national space infrastructure and believes that these university space research programs should continue to perform productive and meaningful research during this period.

D. Space Applications—$651,400,000

The Committee authorizes $651,400,000 for Space Applications—Solid Earth Observations, Environmental Observations, Materials Processing in Space, Communications and Information Systems—in fiscal year 1988. This is $92.1 million greater than the President's budget request. This increase is required to accommodate the launch of the Advanced Communications Technology Satellite in 1990.

Of this amount, $80.8 million is for Solid Earth Observations, $393.8 million is for Environmental Observations, $50 million is for Materials Processing, $104.5 million is for Communications, and $22.3 million is for Information Systems.

1. SOLID EARTH OBSERVATIONS—$80,800,000

The Committee authorizes $80,800,000 for Solid Earth Observations in fiscal year 1988. This represents a $4.0 million augmentation to the President's budget request, to establish a national capability for receiving directly from foreign remote sensing satellites data collected over the United States.

Summary of fiscal year 1988 funding levels

Shuttle/Spacelab payloads	$21,100,000
Geodynamics	33,100,000
Research and analysis	26,600,000
Total solid Earth observations	$80,800,000

The objectives of the Solid Earth Observation Program are to understand the processes controlling the state of the land surface and the interior of the Earth as well as the interaction of the solid Earth with the atmosphere and the oceans. The Solid Earth Observations Program is an integral part of the overall NASA Earth Science and Applications effort to increase understanding of the planet Earth through the study of its dynamics, the physical processes which affect habitability, and solar-terrestrial environment.

Specific land surface objectives include determination of the terrestrial landscape including the biosphere and the hydrosphere and understanding the changes and change mechanisms that are occurring within that landscape. Studies of the cycling of key biogeochemical elements, interactions between the biosphere and the climatic system, and the composition and evolution of crustal rock systems are essential to these objectives.

The geodynamics research objectives include determination of the movements and deformation of the Earth's crust, the processes which drive tectonic plates, the rotational dynamics of the Earth and its interactions with the atmosphere and oceans, the Earth's gravity and magnetic fields, and the interior structure and composition of the Earth. These objectives required precise measurements of crustsal movements and Earth orientation over an extended

period along with accurate knowledge of the variability of the Earth's geopotential fields.

The objective of the Shuttle/Spacelab payload development project is to develop, test and evaluate Earth-viewing remote sensing instruments and systems to obtain data for solid Earth Observations research.

Fiscal year 1988 funding for Shuttle/Spacelab payload development is required for continued development of SIR-C technology and for advanced spectrometer activities including the development of the Shuttle Imaging Spectrometer Experiment.

In fiscal year 1988, measurements of plate motion between North America and Europe will be continued in cooperation with NOAA and several European countries. Measurements of the motions of the Pacific Plate will also be continued in cooperation with DOD and Japan and will be extended to include China. In addition, regional crustal deformation measurements in western North America will continue in cooperation with NOAA, Canada and Mexico. Similar measurements will be initiated in Europe in cooperation with a consortium of 10 European, North African, and Mid-East countries. The Caribbean studies will be continued in fiscal year 1987 and are expected to involve some eight countries in 1988.

Finally, in fiscal year 1988 emphasis will continue on investigations of the Earth's systems which are undergoing stress in order to better understand the processes which control such systems.

Activities will also emphasize studies to determine continental rock type and erosion processes in semi-arid regions in sedimentary basins. Sensor systems such as the Advanced Visible-Infrared Imaging Spectrometer, quad-polarization L- & C-Band imaging radar and the Thermal Visible-Infrared Imaging Spectrometer will be used in these investigations and will serve as prototypes for Shuttle instruments now under development and for future Space Station polar platform instruments. The Thematic Mapper or the operational Landsat will continue to serve as the focal instrument for multidisciplinary investigations, with particular emphasis on the tectonic structure of continental highlands.

Solid Earth Observations—Committee Comments

The Committee authorizes $80.8 million for Solid Earth Observations for fiscal year 1988. This is $4 million more than the President's budget request.

The Committee believes that there is compelling scientific need to increase U.S. access to and utilization of multiple sources of satellite remotely sensed data. For this reason, the Committee has augmented NASA's authorization level for its Solid Earth Observations, Research and Analysis program by $4 million. This reflects the Committee's desire to ensure that the United States develops a capability for the reception of data from current and future operating remote sensing satellites from multiple sources, the reduction of these data for research and development purposes, and the archiving of these data. NASA, in cooperation with the U.S. Geological Survey, the National Oceanographic and Atmospheric Administration and other appropriate federal agencies, should endeavor to

establish capabilities for receiving directly from foreign remote sensing satellites data collected over the United States.

During the past 15 years, the United States has developed and implemented unparalleled capabilities in civil satellite land remote sensing through experimental and operational programs that have led to the recognition of the United States as the world's technological leader in space remote sensing. As the science and technology of satellite remote sensing have evolved, and as important interdisciplinary scientific applications of the data have been developed and implemented, a growing recognition has begun to evolve that this country's capabilities in satellite land remote sensing represent an important national asset.

In the decades ahead, civil satellite land remote sensing will take on even greater importance as a unique source of basic, world-wide information critical to the ultimate success of many of the currently emerging programs on global change. This increased importance of satellite remotely sensed land data and related technology comes at a time when uncertainties surround the future of the United States' Landsat program and place in jeopardy this country's ability to independently meet our own scientific requirements for global satellite remotely sensed data.

However, opportunities exist to minimize the effects of a possible gap in U.S. capabilities through important and beneficial programs of international cooperation with countries such as France, Japan, India, Indonesia, Canada, Brazil, the European Space Agency and others that have launched or soon will launch earth remote sensing satellites. They will acquire global data sets capable of meeting many of our future requirements for scientific information needed to conduct studies and programs of global change and global monitoring.

NASA, working in cooperation with other appropriate federal agencies, is directed to study and initiate implementation of a global land processes information system to include capabilities and facilities to receive (or otherwise obtain), process, and make available data from foreign land remote sensing satellite systems and other appropriate data required for land processes and earth science research and global monitoring programs by federal agencies with responsibility in those areas.

Further, NASA should implement complementary cooperative programs of remote sensing research and development aimed at fully extracting and exploiting the information contained in the data acquired by these various satellite systems, particularly for the purpose of advancing capabilities important to emerging and growing requirements to study and monitor global change.

2. ENVIRONMENTAL OBSERVATIONS—$393,800,000

The Committee authorizes $393,800,000 for Environmental Observations in fiscal year 1988. This is the same as the President's budget request.

Summary of fiscal year 1988 funding for environmental observations

Upper atmosphere research and analysis	$34,400,000
Atmospheric dynamics and radiation research and analysis	32,900,000
Oceanic processes research and analysis	21,500,000

Space physics/research and analysis	21,500,000
Payload and instrument development	19,400,000
Extended mission operations	26,800,000
Interdisciplinary research and analysis	1,100,000
Tethered satellite payloads	3,100,000
Scatterometer	22,700,000
Upper atmosphere research satellite mission	95,400,000
Ocean topography experiment	90,000,000
Global geospace science	25,000,000
Total Environmental Observations	393,800,000

The objectives of the Environmental Observations program are to improve our understanding of the processes in the magnetosphere, atmosphere, and the oceans; to provide space observations of parameters involved in these processes; and to extend the national capabilities to predict environmental phenomena, both short- and long-term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively and sometimes only observed from space. NASA's programs include scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, plasma acceleration, and dynamic processes occurring in the magnetosphere, atmosphere, and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; optimizing the use of space-derived measurements in understanding large-scale weather patterns; advancing our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-sea interactions; improving the knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction; and enabling a comprehensive understanding of solar terrestrial processes and a detailed determination of the physics and coupling between the solar wind, magnetosphere, ionosphere, and atmosphere.

Effective utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation; laboratory research of fundamental processes; development of instrumentation, flight of the instruments on the Space Shuttle, dedicated spacecraft and flights of opportunity; collection of *in situ* ancillary or validation data; and scientific analysis of data. The approach is to develop a technological capability with a strong scientific base and then to collect appropriate data, through remote and *in situ* means, which will address specific program objectives.

Along with the Solid Earth Observations program, the Environmental Observations activities compose an integral part of NASA's total Earth sciences and applications efforts, with emphasis on understanding the Earth as a planet, studying its dynamics, processes, habitability, and solar-terrestrial environment.

Upper atmosphere research and analysis

The upper atmosphere research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere and related phenomena in the lower atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change. The program's three major thrusts are in the areas of upper atmospheric research, stratospheric processes research, and tropospheric chemistry research.

A variety of *in situ* and remote sensing techniques are needed to meet the objectives of determining and understanding the distribution of ozone and other trace species in the atmosphere. Data sets from a limited number of satellites are now generally available to the scientific community, including a record of the global distribution of ozone extending back over a decade, and simultaneous observations of a number of trace constituents. This data is being exploited to determine if trends in the ozone amount have been detected and to understand those processes which are directly involved with these trends.

Recent developments in our understanding of the ozone layer have revealed a possible non-linear dependence of ozone depletion on the amount of fluorocarbon released to the atmosphere. These findings place increased urgency on the need to verify the completeness and accuracy of the theoretical stratospheric model. In fiscal year 1988, tests of the models will be continued by means of field measurements, model calculations, and interpretation of satellite data. The development of more realistic two- and three-dimensional models will be continued. The global data sets from past and present satellites will be further analyzed in fiscal year 1988 to aid in the understanding of large-scale atmospheric processes.

The comparison of ballon, aircraft, and ground-based measurements will be continued in fiscal year 1988 to ensure the validity of the different techniques that have been developed and to observe chemical species in the stratosphere and troposphere to determine the exchange of gases between the lower and upper atmosphere. These balloon and aircraft measurement programs are the only way to measure many of the localized phenomena of the atmosphere, they also help to validate satellite observations. Studies of potential new instruments for use on future satellites and suborbital measurement platforms will also be conducted in fiscal year 1988 to ensure that new technologies are put to use in improving the capability and cost efficiency of tropospheric composition and upper atmosphere measurements.

The recent observations of a depletion in the amount of ozone over Antarctica in the austral spring have attracted a great deal of attention. In order to understand the chemical and dynamical processes that are causing this phenomenon, the Upper Atmospheric Research Program is planning a major aircraft mission in late fiscal year 1987--early fiscal year 1988 using the NASA ER-s and DC-8. Analysis and interpretation of the results of this mission will be a critical effort in fiscal year 1988.

Atmospheric dynamics and radiation research and analysis

The research and analysis activities within the Atmospheric Dynamics and Radiation program comprise a core effort which is fundamental to using space technology to solve problems in atmospheric science. The program's three main thrusts are in the areas of global scale tropospheric processes research, mesocale processes research and climate research.

The objectives of the global scale research program are to improve our understanding of large-scale atmospheric behavior and to develop improved capabilities to observe the atmosphere from space. The program involves the development of advanced remote sensing instrumentation to observe the atmosphere, the development of advanced analysis techniques to better utilize existing meteorological satellite data, and development of advanced numerical models which use satellite observations to describe the state of the atmosphere both diagnostically and predictively.

The objectives of the mesoscale processes research program are to improve our understanding of the behavior of the atmosphere on short (minutes to hours) time scales and over local to regional size scales (severe weather, such as tornadoes and hurricanes).

The Climate Research Program seeks to develop a space capability for global observations of climate parameters which will contribute to our understanding of the processes that influence climate and its predictability. Research is focused in accordance with the National Climate Program priorities wherein NASA has the role of lead agency for solar and Earth radiation research.

A significant research effort on developing the capability to observe rainfall from space has been initiated. This includes studies of instrumentation, sampling requirements, algorithm development and modeling to determine the feasibility of remotely sensing rainfall from space.

Fiscal year 1988 funding is required to provide instruments and support for aircraft flights to study the detail of flows around thunderstorms and fronts, continue development and comparison of numerical models, study atmospheric scale interactions, and develop techniques to display model outputs in 3-dimensions. Analysis of the data collected in interagency field experiments during fiscal years 1986 and 1987 will be performed. In addition, experimental, theoretical, and computational work will be done to better define the capabilities and requirements for the remote measurement of rainfall.

Oceanic Processes Research and Analysis

The Oceanic Processes Research and Analysis (R&A) program emphasizes the development and applications of spaceborne observing techniques to advance our understanding of the fundamental behavior of the oceans, as well as to assist users with the implementation of operational systems. As such, the program operates in concert with a variety of federal agencies (e.g., Navy, NOAA, NSF) and foreign countries (e.g., Canada, Europe, Japan).

The Oceanic Processes R&A program is actively pursuing scientific research with other federal agencies and foreign countries for the World Climate Research Program (WCRP). Component WCRP

efforts include the Tropical Ocean/Global Atmosphere (TOGA) and World Ocean Circulation Experiments (WOCE), a Global Flux Experiment (GFE), and a Program for International Polar Oceans Research (PIPOR).

In fiscal year 1988, the physical oceanography research activities will include implementation planning for WOCE and TOGA, as well as the development of numerical models and associated data assimilation techniques for use in determining the general circulation of the oceans. In biological oceanography, the analysis of data from Nimbus-7 will be continued in order to estimate global ocean productivity, as well as to help with the conceptual design of the Global Flux Experiment. In polar oceanography, emphasis will be placed on the experimental design for the Program for International Polar Oceans Research, which is planned to involve direct reception in Alaska of SAR data from the European Space Agency's ERS-1 and from the Japanese JERS-1 spacecraft due for launch in the 1989-91 time frame.

Advanced technology development activities also will be continued on prospective future sensors for flight aboard both the Shuttle and free-flying spacecraft.

Space physics research and analysis

Space physics research and analysis is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in the solar corona, the interplanetary medium and in the vicinity of the Earth and other planets.

During fiscal year 1988, the space physics research and analysis activities will be continued with particular emphasis on the analysis of data obtained from the 1986 Polar Region and Outer Magnetosphere International Study (PROMIS) campaign and from the International Cometary Explorer (ICE) which collected unique data in the Earth's distant magnetotail before going on to an encounter with the comet Giacobini-Zinner in September 1985. Definition studies will be conducted during fiscal year 1988 for advanced missions such as the follow-on for the United States-Italian Tethered Satellite System, which will investigate atmospheric and electrodynamics effects, a solar proble mission to study the unexplored region between four and sixty radii from the Sun, and Space Station Payloads including the Solar Terrestrial Observatory.

The solar terrestrial theory program will be continued during fiscal year 1988. In addition, a comprehensive and quantitative aggregate model of solar-terrestrial interactions will continue to be developed.

Payload and instrument development

The Space Transportation System offers the unique opportunity for short duration flights of instruments. The Environmental Observations program has incorporated this capability into the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long duration free-flying missions; and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical.

Fiscal year 1988 funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities including data reduction, refurbishment for reflight and upgrading of the ground service equipment.

The initial flight of the Atmosphere Trace Molecules Observed by Specstroscopy (ATMOS) instrument was completed in 1985, with greater than expected science results. The fiscal year 1988 funding is required to support the ground observation program of ATMOS as well as continued science team activities, data processing and analysis, and limited refurbishments.

Fiscal year 1988 funding is also required to continue the Active Cavity Radiometer (ACR) data processing, science team activities, and refurbishment for reflight on future Shuttle ATLAS flights, and development of a free-flyer version of ACR.

Development activities will continue on the international (U.S. and French) Light Detection and Ranging (LIDAR) airborne instrumentation following completion of conceptual definition, breadboard laboratory activities, and preliminary design reviews for this multi-phase user program.

In fiscal year 1988, the Collaborative Solar Terrestrial Research Program (COSTR) will continue development of U.S.-provided instruments for the ISAS/NASA GEOTAIL Mission. NASA also will begin development of U.S.-provided instruments and mission support equipment for the ESA/NASA joint CLUSTER and SOHO missions.

Extended mission operations

The objectives of the extended mission operations program is to provide for the operations, data processing, validation and data analysis of missions which have completed basic operations funded by approved project support.

The Solar Mesosphere Explorer (SME,) launched in October 1981, is providing major input to our overall atmospheric parameter data base. SME is producing simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere, including data measurements of ozone, atomic oxygen, nitric oxide and solar irradiance. Data results indicate greater short-term variations and magnitude than was expected of many of the mesospheric properties. A ground truth program to aid in the validation of the SME data is also being undertaken. SME is providing excellent data on the effect of volcanoes on the Earth's atmosphere.

Solar terrestrial research activities rely on data received from the International Sun-Earth Explorers, (ISEE-1 & 2), the Interplanetary Monitoring Platform (IMP), the Active Magnetospheric Particle Trace Explorer (AMPTE), and the Dynamics Explorers (DE) which are still operational. IMP continues to provide the only available source of solar wind input measurements to the Earth. IMP, along with ISEE-1 & 2, DE, AMPTE, and the Swedish Viking satellite successfully conducted a multisatellite campaign called PROMIS in 1986. The ISEE-3 spacecraft, renamed the International Cometary Explorer (ICE), provided complementary solar wind measurements upstream of Comet Halley in 1986, and was retar-

geted for a return to Earth orbit in 2014 for retrieval and presentation to the National Air and Space Museum (NASM).

Fiscal year 1988 funding is required to support continuing mission operations and data analysis activities for the International Sun-Earth Explorers, the Interplanetary Monitoring Platform, the Dynamics Explorer, International Cometary Explorer, and the Active Magnetospheric Particle Trace Explorer. Operation of the Nimbus and SME satellites and processing of the collected data will be continued as will activities to provide ground truth for a NASA-developed ozone instrument to be flown on a NOAA meterological satellite.

In addition, fiscal year 1988 funding is required for operating the Earth Radiation Budget Satellite (ERBS) spacecraft, data processing and analysis from the total three-instrument system, and from the SAGE-II instrument on ERBS.

Interdisciplinary research

Interdisciplinary research activities need to be conducted to quantitatively characterize the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes.

In fiscal year 1988, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of Oceanic Processes, Atmospheric Dynamics and Radiation, Upper Atmosphere/Troposphere Chemistry, and Land Processes into a unified program which will help increase our understanding of critical global processes.

Tethered Satellite Payloads

The Tethered Satellite System (TSS) will provide a facility for conducting experiments weighing 500 kg or less from distances of 100 km above or below the Space Shuttle. The TSS will allow unique science to be undertaken such as observations of atmospheric processes occurring within the lower thermosphere (below 180 km altitude), observations of crustal geomagnetic phenomena, and direct observation of magnetospheric-ionospheric-atmospheric coupling processes in the 125–180 kilometer region.

The TSS is an international cooperative project with the Italian government. The United States is developing the tether deployment and retrieval system and is responsible for overall project management and system integration, development and integration of the U.S.-provided instruments, and flight on the Shuttle. Italy is developing the satellite and is responsible for development and integration of Italian-provided instruments. An Announcement of Opportunity for investigations was issued in April 1984. Selection of investigators was completed in late 1985, and instrument design initiated in 1986.

The fiscal year 1988 funding is required to continue development of U.S.-provided instruments on TSS–1 and core equipment development and integration.

Scatterometer

The Scatterometer will provide accurate, global measurements of ocean surface winds which will be useful for both oceanography and meteorology. In addition to providing wind field data, Scatterometer data will permit the first global study of the influence of winds on ocean circulation, provide data on the effects of the oceans on the atmosphere, and provide improved marine forecasting (winds and waves). Flight of the instrument in 1990–91 will provide an overlap of data gathering with the World Ocean Circulation Experiment, Tropical Ocean-Global Atmosphere Experiment planned by the international oceanographic community; and additionally, concurrent flight with the Ocean Topography Experiment (TOPEX) would result in unique measurements of the oceans' driving force (winds) and the resulting ocean response (topography).

Pursuant to a recent decision by the Secretary of the Navy, the Scatterometer will be flown on the Navy Remote Ocean Sensing System (N-ROSS) satellite in late 1990. This is a reversal of the position taken in the fiscal year 1988 DOD budget request that would have terminated the N-ROSS program and forced the Scatterometer to fly on an alternative spacecraft.

Planned fiscal year 1988 activities will include the continuation of hardware development leading to testing and integration of the Scatterometer Flight Model, delivery of the second computer system and beginning of its testing, and continued refinement of post-launch research and verification plans.

Upper Atmosphere Research Satellite Program

The Upper Atmosphere Research Satellite (UARS) program is the next logical step in conducting a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. This mission, scheduled for a STS launch in 1991, is essential for understanding the key radiative, chemical and dynamical processes which couple together to control the composition and structure of the stratosphere. The UARS mission will provide the first integrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesosphere.

The fiscal year 1988 funds are required for continuation of the development of the ten UARS instruments including flight hardware fabrication, instrument assembly and environmental testing leading to instrument delivery to the spacecraft in 1989. In addition, the spacecraft development and hardware fabrication activities will continue.

The ground data handling facility will enable a higher level of interaction among experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that the system be developed on a timely parallel path with the flight hardward so that individual experiment data processing subsystems, including algorithms and the interactive data base, provide maximum interaction and effectiveness in the design and development phase of the program and are fully verified at launch time. In order to achieve this, fiscal year 1988 funding is required

to continue design and development of the ground data handling facility including hardware delivery and checkout, software preliminary and critical design reviews, science team support and science algorithm development.

Ocean Topography Experiment

The goal of the Ocean Topography Experiment (TOPEX) is to utilize satellite radar altimetry to measure the surface topography of the global oceans over a period of three years with sufficient accuracy and precision to significantly enhance our understanding of the oceans' general circulation and its mesoscale variability. Such information is needed to better understand how the atmosphere drives the circulation of the oceans, how the oceans in turn influence the atmosphere, and ultimately, the role of the oceans in climate.

On March 23, 1987, NASA and the French Space Agency (CNES) signed a Memorandum of Understanding (MOU) to collaborate on TOPEX in order to more fully exploit the scientific value of the data. Under the terms of the MOU, NASA will provide a spacecraft bus and several instruments including a radar altimeter, a microwave radiometer, and tracking systems whereas the French will provide a French altimeter and tracking system and will launch TOPEX in late 1991 usiong Ariane. TOPEX is also being planned in concert with the World Ocean Circulation Experiment (WOCE), a major international oceanographic field program being planned under the auspices of the World Climate Research Program (WCRP). WOCE will combine satellite observations from TOPEX with traditional *in situ* observations to enable the first comprehensive determination of the three-dimensional current structure of the global oceans. When further combined within ocean surface winds from the NASA Scatterometer (NSCAT), unique measurements of the oceans' driving force (winds) and the resulting ocean response (topography) will have been obtained.

In fiscal year 1988, preliminary design of the satellite and ground data systems will be well under way. Sensor development will continue through the Critical Design Review phase leading to the initiation of fabrication by late fiscal year 1988. At the same time, the science team will be refining their research plans and will assist in design options as they relate to achieving scientific success with TOPEX.

Global Geospace Science

The Global Geospace Science (GGS) is proposed as a fiscal year 1988 new initiative and will be part of the United States' contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a new and comprehensive understanding of the interaction between the Sun and the Earth.

The GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program initiated in fiscal year 1987 to provide instruments and launch support and to gain science return in a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronauti-

cal Science (ISAS). The scientific value of this effort would be greatly enhanced by the addition of the two spacecraft proposed in the GGS program. The combined program would include five spacecraft missions: two U.S. spacecraft, WIND and POLAR; two ESA spacecraft, SOHO and Cluster; and one ISAS spacecraft, GEOTAIL. NASA will launch and provide upper stages for all spacecraft except SOHO. ESA will provide for launch and associated costs for SOHO. Initiation of GGS in fiscal year 1988 will move the U.S. from a supporting to a leadership role in this international cooperative program.

The Global Geospace Science (GGS) mission will measure and model the effects of the Sun on the Earth's space system to enhance our understanding of the processes and flow of energy and matter in the solar energy chain from outer geospace to atmospheric deposition. GGS will also enhance our ability to assess the importance of variations in atmospheric energy deposition from the geospace system to the terrestrial environment.

Essentially, all commitments by the foreign governments are in place, and their development activities have commenced. Approval of the GGS will allow the United States to become a full partner in the ISTP program reinforcing our commitment to international coopertion and is essential to maintaining continued leadership in solar terrestrial physics.

Fiscal year 1988 funds are required to initiate development of GGS spacecraft instruments and ground system. Fiscal year 1988 funding will allow initiation of these effects in time to take advantage of simultaneous measurements provided by the Collaborative Solar Terrestrial Research (COSTR) program and other solar-terrestrial research efforts.

Environmental Observations—Committee Comments

The Committee authorizes $393.8 million for Environmental Observations for fiscal year 1988. This is the same as the President's budget request.

The Committee was pleased to be informed that on March 23, 1987, NASA and the French Space Agency (CNES) signed a Memorandum of Understanding to collaborate on the Ocean Topography Experiment (TOPEX). This cooperative venture should enhance the standing of the United States in the international community and assist our understanding of global ocean dynamics. TOPEX is scheduled to be launched in late 1991 on a French Ariane vehicle.

The Committee also was pleased to see the Upper Atmosphere Research Satellite (UARS) on the October 1986 space shuttle manifest for the 4th quarter of 1991. Although this mission has been delayed two years by the *Challenger* disaster, there is still a great deal of support on the Committee for the UARS mission since it will provide the first integrated global measurements of ozone concentration and chemical species that affect ozone.

The recent reinstatement of the Navy Remote Ocean Sensing System (N-ROSS) by the Secretary of the Navy has been well received by the Committee. NASA has been developing the scatterometer to fly on N-ROSS. The flight of both the N-ROSS Mission

and the TOPEX Mission simultaneously will significantly enhance the scientific return from these missions.

Finally, the Committee has fully authorized the fiscal year 1988 NASA budget request for the Global Geospace Science (GGS) proposal—the only "new start" included in the President's budget request. The GGS proposal is an international, multi-spacecraft mission designed to improve the understanding of the interaction between the Sun and the Earth. Approval of this proposal by the Committee should permit the United States to maintain its leadership in solar terrestrial physics.

3. MATERIALS PROCESSING IN SPACE—$50,000,000

The Committee authorizes $50,000,000 for Materials Processing in Space in fiscal year 1988. This is $4.1 million greater than the President's budget request.

The Materials Processing in Space program emphasizes the science and technology of processing materials to understand constraints imposed by gravitational forces and unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in fiscal year 1988 are being concentrated on six major processing areas: metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. These activities will provide the scientific basis for future space applications of materials processing technology as well as provide a better understanding of how these processes occur on the ground. Definition studies will be performed for Shuttle and Space Station experiment candidates in areas such as containerless experiments, combustion science, solidification and crystal growth, and blood storage.

The Microgravity Shuttle/Space Station payloads budget supports a consolidation of ongoing activities which provide a range of experimental capabilities for all scientific and commercial participants in the Microgravity Science and Applications program. These include Shuttle mid-deck experiments, the Materials Experiment Assembly and the Materials Science Laboratory, which is carried in the orbiter bay.

In fiscal year 1988, effort will continue at the centers for bioprocessing research located at the University of Arizona and the University City Science Center in Philadelphia, PA as well as the Microgravity Materials Science Lab at the Lewis Research Center.

Fiscal year 1988 funding also is required to continue basic and applied research activities using mid-deck and cargo bay experiments leading to several flights over the next few years. Investigations will be planned in fluid dynamics, glasses, electronic materials, biotechnology, metals and alloys, and combustion. Development will begin on a number of Physics and Chemistry Experiments (PACE) as well as continued development of several pieces of advanced equipment in the areas of electronic crystal growth, biotechnology, metallic casting, and levitation.

Funding will also support definition activity for Space Station hardware development.

Materials Processing in Space—Committee Comments

The Committee authorizes $50 million for Materials Processing in Space in fiscal year 1988. The increase of $4.1 million above the President's budget request is to accommodate additional hardware/instrumentation development activities that will better position the program when space shuttle flights resume.

The Committee is most supportive of NASA's materials processing activities and believes that the long-term returns from this program will be substantial. The Committee is concerned, therefore, with the Findings and Consequences of the Interim Dunbar Report that point to possible erosion of the microgravity science community, inadequate preparedness for space station, and the loss of international competitive advantage. The Committee expects NASA to seriously review this report and its recommendations and to initiate corrective actions as soon as possible.

The Committee also expects to be kept well informed of any developments in the Centers of Excellence Program. The Committee is sensitive to the effect of the loss of flight opportunities on the Centers' activities. However, these Centers of Excellence are expected to yield significant breakthroughs and establish foundations for more sophisticated research in space, and, therefore, NASA is expected to maintain the highest standards for this program.

4. COMMUNICATONS—$104,500,000

The Committee authorizes $104,500,000 for Communications for fiscal year 1988. This is $84 million greater than the President's budget request to accommodate the launch of the Advanced Communications Technology Satellite in 1990.

Summary of Funding for Fiscal Year 1988

Advanced commications technology satellite (ACTS)	$84,000,000
Research and analysis	14,400,000
Search and rescue	1,300,000
Technical consultation and support studies	3,400,000
Experiment coordination and operations support	1,400,000
Total Communications	104,500,000

The Communications Research and Analysis program continues to provide the development of subsystem component technology required by NASA, other government agencies, and U.S. industry for advanced communications satellite systems. Special emphasis is being given to pursuing technologies with high potential for improving spectrum utilization, satellite switching, and intersatellite link technologies, since these technologies are the key to future growth of the communication satellite and terminal markets. In addition, the mobile communications technology program will continue to address the development of critical enabling technologies needed to insure growth of a commercial mobile satellite service in the United States. This effort, in cooperation with U.S. industry, Canada, and other government agencies, will help implement a first generation commercial system at the end of the decade.

Advanced Communications Technology Satellite

The objective of NASA's Advanced Communications Technology Satellite (ACTS) Program is to prove the feasibility of certain advanced communications technologies through a flight test program.

The specific technologies to be validated include: (a) the use of multiple fixed and scanning spot antenna beams; (b) frequency reuse; (c) beam interconnectivity at both intermediate frequencies and at baseband; (d) advanced system network concepts; and (e) dynamic rain-compensation techniques. These technologies will apply to a wide range of communications systems in the 1990s. A contract was signed in August 1984 to develop the flight and ground hardware.

The ACTS spacecraft is scheduled to be launched in 1990 from the shuttle into geostationary orbit. The spacecraft will consist of a commercial communications package, including a multibeam antenna, baseband processor, RF matrix switch, traveling wave tube amplifier, and low noise receiver. The ground segment will consist of a NASA ground station and a master control station. Following launch and checkout, a 2-year program of user-funded experiments will be initiated during which time ACTS system technologies will be tested, evaluated, and validated. To date, over 80 organizations, including DOD, have requested consideration for over 118 experiment opportunities on ACTS.

Research and analysis

The Communications Research and Analysis program emphasizes the development of high-risk technology required to maintain U.S. preeminence in the international satellite communications market, to enable new and innovative public services, and to meet the communications needs of NASA and of other government agencies. This program focuses on the "interconnectivity technologies" of on-board switching, intersatellite links, and antennas, as well as advanced radio frequency (RF) technologies. Advanced studies are performed to determine the future satellite communications needs of the country and to define the technology required to meet those needs. The technology is developed and tested through an advanced proof-of-concept (POC) program. The POC devices and components are then integrated into a multiple terminal, satellite communications network in a laboratory where they undergo comprehensive evaluation.

The mobile communications technologies activity is aimed at accelerating the introduction of a commercial mobile satellite service in the United States and developing and testing power, bandwidth and orbital-slot efficient ground segment technology and networking techniques needed to insure its growth.

During fiscal year 1988, advanced studies and selected technology development will continue in the high risk areas of microwave and optical technology, satellite switching, RF systems, and intersatellite links. Work in these technology areas will support U.S. industry, NASA, and other government agencies and address national economic and security interests.

In fiscal year 1988 all prototype components for the mobile communications technology experiment will be completed, and field testing of the full mobile terminal will begin.

Search and Rescue

The Search and Rescue program, developed by NASA and international partners, has demonstrated the feasibility of using satellites to improve significantly the ability to detect and locate general aviation aircraft and marine vessels during emergencies. The Search and Rescue satellite system has met all specifications and was declared operational in July 1985. The system has received world-wide acclaim and has been credited with saving over 675 lives to date. In addition, the system is demonstrating the potential to save millions of dollars annually in search logistics costs.

In fiscal year 1988, an experiment using geostationary satellites for instant alert will be completed and the results analyzed. Work to improve cost and performance of emergency beacons will continue.

Technical consultation and support studies

Technical consultation and support provide the technical basis for regulatory and policy development to assure the orderly growth of existing and new satellite services. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. Emphasis is placed on orbit and spectrum utilization studies, which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effect of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary satellite orbit and the radio spectrum.

In fiscal year 1988, work will be completed on the geostationary orbit arc allotment planning method, and support will continue for the second session of the Space World Adminstrative Radio Conference. Studies will continue for the purpose of identifying techniques to increase the efficient use of the limited orbit/spectrum resources and to understand and alleviate the adverse effects of propagation phenomena on space communications.

Experiment coordination and operations support

The objectives of this program are to support and to document a wide range of user experiments and demonstrations of the application of satellite communications. Past experiments on experimental satellites, such as the Applications Technology Satellite (ATS) series and the Communications Technology Satellite (CTS), have successfully provided users with the experience necessary to make informed decisions regarding the satellite communications functions. NASA's role to stimulate use of unique space facilities has led to wider application of commercial satellites that better meet the needs of potential users.

The remaining Applications Technology Satellite, ATS-3, continues to support the National Science Foundation, the National Oceanic and Atmospheric Administration, several universities, state and local governments, and a number of domestic and international disaster relief organizations. Support is provided through satel-

lite voice and data links for scientific and communications experiments to North and South America, most of the Atlantic Ocean, and a large part of the eastern Pacific including Hawaii and Antarctica.

In fiscal year 1988, operational support for ATS-3 will continue. NASA will maintain approval and policy control of the ATS program. NASA will continue planning support for educational, scientific, and public service communications experiments for organizations within the Western Hemisphere, and will support similar experimental activities of Pacific basin organizations within the footprint of the ATS-3 coverage.

Communications—Committee Comments

The Committee authorizes $104.5 million for Communications for fiscal year 1988 including $84 million for the Advanced Communications Technology Satellite (ACTS) that is scheduled for launch in November, 1990.

The Committee strongly supports the ACTS program because it is critical to the future of the United States in the world communications market. Furthermore, the Committee continues to believe that the development of the ACTS technologies is an appropriate research and development function for NASA.

The Committee finds that the Office of Management and Budget justification for the exclusion of any funding request for ACTS in fiscal year 1988 is without merit. The Committee expects funding for the ACTS program to be included in the fiscal year 1989 budget submission.

At a time when the United States suffers from an adverse balance of trade and the Europeans and Japanese are mounting substantial threats to our share of the world communications market, the Committee believes it is essential that the government and private sector cooperate to share the high costs and risks associated with the development of new technologies. The ACTS program is patterned on such a cooperative venture and represents a conscious effort on the part of the Congress to sustain the Nation's leadership in communications.

The Committee instructs NASA to proceed vigorously with the ACTS program and to have the satellite ready for launch in 1990—which is one to two years prior to the expected launch of competing foreign experimental satellites.

5. Information Systems—$22,300,000

The Committee authorizes $22,300,000 for Information Systems for fiscal year 1988. This is the same as the President's budget request.

The objectives of the Information Systems program are to: develop and demonstrate advanced capabilities of managing; distributing, and processing data and information; implement information system standards and provide common software in order to lower data system costs; and develop the basis for data services to provide improved access to, and rapid delivery of, space data and advanced data systems in support of the nation's satellite programs and space science and applications projects.

The fiscal year 1988 Information Systems funding is required to provide support for space science and applications programs. Funds are required: to continue development of planetary, Earth resources, and astrophysics data systems projects which are being implemented at the Jet Propulsion Laboratory, the Goddard Space Flight Center, and participating academic institutions; to continue implementation of on-line data directories and catalogs; to operate the large-scale computers in the Space and Earth Sciences Computing Center (SESCC) and the archives at the National Space Science Data Center (NSSDC) (both facilities located at the Goddard Space Flight Center); to develop common software to support ongoing research in the space and Earth sciences; and to continue development of data management and data archiving to support flight projects, discipline program offices, and other NASA program offices. The FY 1988 funding levels will also provide the university/research community with improved access to NASA computational facilities and data archives by expanding network communications links, by increasing online data storage capacities, and by developing standards for data and protocols.

Information Systems—Committee Comments

The Committee authorizes $22.3 million for Information Systems in fiscal year 1988. This is the same as the President's budget request.

The Committee strongly supports the development and demonstration of advanced information systems and believes they are critical to the success of the Nation's space program.

E. Commercial Programs—$49,000,000

The Committee authorizes $49,000,000 for Commercial Programs in fiscal year 1988. This is a reduction of $5 million from the President's budget request.

Summary of funding for fiscal year 1988

Technology utilization	$18,300,000
Commercial use of space	30,700,000
Total commercial programs	49,000,000

Technology Utilization

The NASA Technology Utilization Program is designed to strengthen the national economy and industrial productivity through the transfer and application of aerospace technology resulting from NASA's R&D programs. To accomplish this objective, NASA has established and operates a number of technology transfer mechanisms to provide timely access of useful technologies to the private and public sectors of the economy. Almost every part of U.S. industry is affected by the technology transfer process, especially in such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation and safety are areas in which aerospace technologies have been especially beneficial. The specific objectives of the program are:

to accelerate and facilitate the application of new technology into the commercial sector, thus shortening the time between the generation of advanced aeronautics and space technologies and their effective use in the economy;

to encourage multiple secondary uses of NASA technology industry, education, and government, where a wide spectrum of technological problems and needs exist; and

to develop applications of NASA's aerospace technology, including its unique facilities, to priority non-aerospace needs of the Nation.

NASA has continued its broad and comprehensive efforts to promote and encourage the effective application and use of new and innovative aerospace technologies throughout the public and private sectors of the U.S. economy. Of particular note is the upward growth of industrial and business subscribers to *NASA Tech Briefs* which now exceeds 130,000 readers. This 60 percent increase since January 1985 represents a growth rate averaging over 5,000 new subscribers per month . . . an effective measure of the importance and value which U.S. industry places on new and emerging technologies.

Moreover, the NASA-sponsored Industrial Applications Center (IAC) network has made significant strides in developing effective linkages with state-sponsored institutions engaged in industrial and economic growth. This broadening and strengthening of the nationwide technology transfer network is continuing to gather momentum with nearly 20 of the 50 states now being linked to transfer products and services available through the IAC efforts. NASA expects to continue this effort during the balance of fiscal year 1987 and on into fiscal year 1988.

An additional milestone was reached in late 1986 when the Federal Laboratory Consortium (FLC) for Technology Transfer (formerly established under P.L. 99-502) and NASA elected to enter into an agreement which establishes formal linkages between the NASA IAC network and the various Federal laboratories. Based on the successful completion of an experimental program between the NASA IAC at the University of Southern California and the FLC Farwest Region, IAC industrial clients will now be able to gain controlled access to Federal laboratories nationwide that are engaged in research and development activities of paralled commercial interest. This effort should spur and accelerate the process for the transfer and application of federally sponsored technologies into the mainstream of the U.S. economy.

Commercial Use of Space

The goal of the Commercial Use of Space Program is to provide a national focus in support of the expansion of U.S. private sector investment and involvement in civil space activities, while emphasizing new high technology commercial space ventures and promoting the development of new markets for civil space services. The specific objectives of the program are to:

Establish close working relations with the private sector and academia to encourage investment in space technology and the use of the *in situ* attributes of space—vacuum, microgravity, and radiation for commercial purposes.

Facilitate private sector space activities through improved access to available NASA capabilities.

Encourage an increase in private sector investment in the commercial use of space independent of NASA funding.

Develop and implement commercial space policy NASA-wide.

In order to maintain momentum in commercial use of space activities, NASA will continue to establish Centers for the Commercial Development of Space (CCDS). Institutions with strong research capabilities in sciences and engineering, in collaboration with industy and/or industrial associations, will be encouraged to participate. The Centers are joint undertakings involving, to the extent practicable, teams of industrial corporations and/or government agencies (other than NASA) and/or non-profit institutions. Resources support and technical assistance will be partially furnished by NASA with the remainder furnished by the Center members.

In fiscal year 1985, NASA provided partial funding to establish five Centers for the Commercial Development of Space. In fiscal year 1986, NASA funded four additional Centers for a total of nine CCDS in operation. Awards are planned for fiscal year 1987 and fiscal year 1988 for an eventual total of up to 18 Centers simultaneously operating. NASA's individual CCDS funding is planned for five years in order to stimulate and stabilize the Center's activities. Nevertheless, NASA's support, on a year-to-year basis, will depend on a favorable annual review of the Centers' progress in stimulating commercial use of space. There is a mandatory requirement for industry participation in each Center, including the expenditure of corporate resources. NASA support will be reduced and finally discontinued at the end of five years as the successful Centers achieve self-sufficiency.

NASA's goal of expending opportunities for U.S. private sector investment and involvement in civil space and space-related activities will be partially achieved by increasing the amount of space-related research conducted by the private sector, the number and type of NASA and private sector facilities available for space use, and the private sector awareness of the opportunity to use NASA's terrestrial and space-based facilities for potential commercial research.

Through coordination with various industrial sectors, the commercial R&D enhancement efforts will provide generic, multi-use research experimentation equipment. This equipment, as well as ground-based hardware, software and analytical tools will be developed in order to expand the technical research data base on the commercial uses of space required by the private sector to help make economic decisions to commit to research and, potentially, manufacture. Emphasis is placed on building the required technical infrastucture. The main thrust of the effort will be directed by the private sector in coordination with NASA. Resources will also be made available to obtain flight support experimentation hardware required by industrial researchers.

Commercial Programs—Committee Comments

The Committee authorizes $49.0 million for Commercial Programs for fiscal year 1988. This includes $18.3 million for Technology Utilization and $30.7 million for the Commercial Use of Space. This is $5 million less than the President's budget request which represents a general reduction to Commercial Use of Space to be made at the discretion of the Administrator.

The NASA Technology Utilization Program was created to ensure that technology developed for NASA aerospace research could be transferred to other areas. One of the areas in which technology transfers has been successful is in adapting aerospace technology to meet the unique needs of individuals with physical disabilities. This has resulted in advancement in voice controlled wheelchairs, communication aids, and prosthestic devices, etc., which have allowed individuals with physical disabilities to have greater access to education, employment, housing and recreation resulting in greater independence and productivity for these individuals.

The Committee, therefore, directs NASA's Technology Utilization Program to place additional emphasis on its projects and activities in applying technology to meet the needs of individuals with disabilities in the areas of employment, education, housing and recreation, as well as the dissemination of information on such technology transfers to persons and organizations involved with disabilities. In addition, the Committee directs NASA's Technology Utilization Program to report back to Congress within 180 days on what they are currently doing nationally in applied technologies with regard to employment, education, and housing, as well as how they are disseminating information on such technology transfers.

The Committee continues to support the Commercial Use of Space Programs and the establishment of Centers for the Commercial Development of Space. Yet, the Committee is concerned about the effect that the grounding of the space shuttle and the current unavailability of flight opportunities could have on the program/project plans of the Centers. Consequently, it might even be necessary to extend the original financial commitment that NASA made to those Centers beyond three years.

In light of these developments, the Committee recommends that NASA perform a mid-course reassessment of the program's goals, objectives, funding requirements, and flight opportunities prior to the solicitation for additional Centers in fiscal year 1988.

The Committee is most supportive of the Office of Commercial Programs' efforts to build multi-use, multi-user government hardware that will reduce individual entrepreneur experiment costs to a level that can be afforded. The Committee supports full funding of these activities in fiscal year 1988 and believes the availability of this hardware will substantially increase interest in the program and broaden the base of participation to entrepreneurs and small non-aerospace firms.

F. Aeronautics and Space Technology—$375,000,000

The Committee authorizes $375,000,000 in fiscal year 1988 for Aeronautics and Space Technology. This is the same as the President's budget request.

Summary of fiscal year 1988 funding levels

Research and technology base	$285,200,000
Systems technology programs	89,800,000
Total Aeronautics and Space Technology	375,000,000

The goal of the NASA aeronautical research and technology program is to conduct effective and productive aeronautical research and to develop technology which contributes materially to the enduring preeminence of U.S. civil and military aviation. This goal is supported by five comprehensive program objectives: (1) identify and concentrate on those emerging technologies with potential for order-of-magnitude advances in aircraft capability and performance that will enhance U.S. industrial competitiveness; (2) sustain the excellence of NASA's research centers by modernizing and enhancing the efficiency of national facilities, advancing scientific and engineering computational capabilities, and enhancing staff technical excellence by selecting highly qualified personnel and providing them with challenging career opportunities; (3) ensure timely and efficient transition of research results to the U.S. aerospace community through reports, conferences, workshops, and active participation of industry in contractual and cooperative programs; (4) ensure the strong involvement of universities in NASA's program to broaden the nation's base of technical expertise and innovation; and (5) provide technical expertise and facility support to the DOD, other government agencies, and U.S. industry for major aeronautical programs.

1. RESEARCH AND TECHNOLOGY BASE—$285,200,000

The Committee has authorized $285,200,000 for fiscal year 1988 for Research and Technology Base. This is the same as the President's budget request.

Summary of fiscal year 1988 funding levels

Fluid and thermal physics research and technology	$29,000,000
Applied aerodynamics research and technology	61,000,000
Propulsion and power research and technology	41,000,000
Materials and structures research and technology	42,000,000
Information sciences research and technology	26,000,000
Controls and guidance research and technology	27,600,000
Human factors research and technology	26,000,000
Flight systems research and technology	26,100,000
Systems analysis	6,500,000
Total research and technology base	285,200,000

Fluid and thermal physics research and technology

The fluid and thermal physics research and technology program is a combined analytical and experimental research effort directed at external aerodynamics.

A principal objective is the development of computational methods to enhance the ability to predict and simulate aerodynamics flow fields for complete aircraft or missile configurations in any flight condition.

In fiscal year 1988, the fluid and thermal physics program will focus upon 3-D configuration analysis and design. Particular focus will be given to validating Navier-Stokes prediction codes.

Applied aerodynamics research and technology

The objective of applied aerodynamics research is to generate advanced technology to improve the performance and flight dynamics of future aircraft and missiles through analytical and experimental programs.

This effort is directed at specific technology goals in all classes of aircraft: subsonic, rotorcraft, short takeoff and vertical landing (STOL), supersonic and hypersonic.

In fiscal year 1988, activites will focus upon subsonic and rotocraft technologies including reduced drag, laminar flow wings and uncoventional configurations. Additional work will be performed in the supersonic and hypersonic areas.

Propulsion and power research and technology

The objective of the propulsion and power research and technology program is to provide the understanding of the governing physical phenomena at the disciplinary, component, and subsystem levels that will support and stimulate future improvements in propulsion system performance capability, efficiency, reliability, and durability. Research is being performed on a wide variety of subsystems with applications ranging from the general aviation class through hypersonic/aerospace planes.

Major emphasis will be in the hypersonic/supersonic cruise areas and in further development of fuel-efficient propulsion systems.

In 1988, activities will focus upon the development of the analytical and experimental data base for supersonic combustion and Mach 3-6 high speed cruise systems, as well as all other propulsion-related areas.

Materials and structures research and technology

The objectives of the materials and structures research and technololgy program are to: (1) investigate and characterize advanced metallic, ceramic, polymer, and composite materials; (2) develop novel structural concepts and design methods to exploit the use of advanced materials in aircraft; (3) advance analytical and experimental methods for determining the behavior of aircraft structures in flight and ground environments; and (4) generate a research data base to promote improvements in performance, safety, durability, weight reduction, and economy in aircraft.

The development of high temperature, higher reliability ceramic materials for use in engines has produced significant results. Other research into composites, aeroelasticity and hypersonics has also been fruitful.

In fiscal year 1988, research on materials will concentrate on advancing the understanding of material behavior, properties, microstructures, and processing paramenters for advanced metallic, ce-

ramic, polymer, and composite materials. In the structures area, emphasis will be placed on development of innovative structural concepts for composites using advanced filament winding and pultrusion, as well as design concepts using high-temperature brittle materials.

Information sciences research and technology

The objectives of the information sciences research and technology program are to increase NASA's capabilities in advanced aerospace computing and to exploit key computer science disciplines to meet the agency's unique computing requirements. Support for computational fluid dynamics (CFD) and other aerospace research disciplines is provided by developing a fundamental understanding of the relationships between essential algorithms and advanced architectures and exploting the potential of concurrent processing to singificantly increase computing power.

In fiscal year 1988, research in matching computer architectures and algorithms will continue to serve NASA's needs for efficient processing of aerospace algorithms. Investigations of the most advanced supercoputers, such as the Cray 2, and their use for computational fluid dynamics research and similar problems will continue.

Controls and guidance research and technology

The objectives of the controls and guidance research and technology program are to: (1) investigate emerging controls, guidance, artificial intelligence, and display technologies which offer automation/system integration for aviation effectiveness and efficiency; (2) develop architectures for flight-crucial systems for future aircraft and devise analytical methods and techniques for assessing their reliability and performance; (3) develop methods to alleviate the threat of wind shear and heavy rain though airborne detection and avoidance; (4) develop advanced controls and guidance theories and analysis methods for extending the performance envelope and reliability of highly augmented future aircraft; and (5) explore new concepts for achieving integration of multidisciplinary technologies.

In fiscal year 1988, a key goal is to develop robust control algorithms which are resistant to vehicle or environment uncertainties. Additionally, nonlinear modeling and system identification methods are being developed to support high angle-of-attack controls requirements. In the flight-crucial systems area, research will stress validation techniques, assessment technology, software reliability, lightning effects, and advanced architectures.

Human factors research and technology

The objective of the aeronautical human factors research and technology program is to provide the capability to design effective crew-cockpit systems using advanced cockpit automation technologies which will properly integrate the diverse systems, operators, and procedures. This is necessary for safety, efficiency, and increased capability in transcentury rotorcraft and transports and, ultimately, in the National Aerospace Plane.

In fiscal year 1988, research will continue in the areas of pilot error in operational aviation environments, as well as in cockpit design and automation.

Flight systems research and technology

The objective of the flight systems research and technology program is to provide the necessary research and technology development for an improved and validated base of advanced technology for application by industry to future generations of the entire spectrum of aircraft.

Major thrusts of this program are flight safety, flight instrumentation, and flight support.

In fiscal year 1988, the aviation safety program will emphasize coordinated wind tunnel and analytical investigations of ice accretion and its effects on fixed- and rotary-wing aircraft performance and handling qualities. Research to establish a flight-validated severe storms and lightning effects data base will be completed and the results reported to the FAA and industry. Flight test support of flight research projects will continue using a variety of both fixed- and rotary-wing aircraft.

Systems analysis

The objective of the systems analysis effort is to identify and quantify the impact of emerging technologies in aerodynamics, materials, structures, propulsion, and systems that can lead to new plateaus or major improvements in civil or military aircraft of the future, create new markets, and provide potential economic benefits. Systems analysis studies of subsonic aircraft, which include general aviation, commuter, and transport aircraft, concentrate on the impact of very advanced materials and structures for propulsion systems on a 150-passenger class of transports powered by advanced turboprops and on a 500-passenger class of transports powered by turbofans.

In fiscal year 1988, rotorcraft efforts will assess the impact of advanced technologies on high-speed tilt rotor configurations and X-wing concepts. The high-speed civil transportation studies will also continue through fiscal year 1988. Systems studies for advanced high-performance aircraft will focus on new capabilities enabled by key technology developments in high thrust-to-weight ratio propulsion, propulsive control, and systems integration.

2. SYSTEMS TECHNOLOGY PROGRAM—$89,800,000

The Committee has authorized $89,800,000 for fiscal year 1988 for Systems Technology Programs. This is the same as the President's budget request.

Summary of Fiscal Year 1988 funding levels

Rotocraft systems technology	$5,000,000
High-performance aircraft systems technology	14,600,000
Advanced propulsion systems technology	30,500,000
Numerical aerodynamic simulation	39,700,000
Total Systems Technology Program	89,800,000

Rotocraft systems technology

The rotorcraft systems technology program consists of research conducted on two fronts. The first element focuses on advanced technology applicable to the broad class of rotorcraft, with a present focus on reducing noise and vibration and increasing the performance of helicopters. The second element consists of research leading to new, enabling rotorcarft concepts with vastly greater capabilities, such as triple the speed, range, and altitude of current generation helicopters.

In fiscal year 1988, the NASA/American Helicopter Society (AHS) cooperative industry noise research program will conclude with the release of the operational version of the comprehensive noise prediction code called ROTONET. A task of this program will be a design exercise for a low noise rotor with practical operational limitations with a view toward validating improvements in the technology. An effort will also be accelerated to gather a modern data base on rotor airloads with comprehensive measurement of pressures, structural shears, pilot control activity, and acoustics.

High-performance aircraft systems technology

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research, and flight research tests of advanced aircraft concepts and systems.

A particular focus of the program has been the turbine engine hot section technology (HOST) program.

In fiscal year 1988, the flight research activity will involve a variety of high-performance aircraft to investigate advanced concepts. Several projects will continue their flight phases during this period. The turbine engine hot section technology element and the ceramics for turbine engines element have been combined and augmented to form the advanced high-temperature engine materials program in the Advanced Propulsion Systems Technology program. The programs were combined to focus the efforts on developing fundamental technology for revolutionary advances in high-temperature materials for advanced propulsion systems and will be reported under advanced propulsion systems technology.

Advanced propulsion systems technology

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

Activities in the advanced turboprop systems program are devoted to establishing concept feasibility and providing the broad research and technology analytical and experimental data base necessary for achieving the concept's full potential.

In the general aviation and commuter engine technology program, will the objective of raising the performance level of small

turbine engines to more nearly match that of large engines, the work continues to be focused on providing fundamental experimental data to obtain a detailed understanding of the design parameters that affect component performance as size is reduced.

In fiscal year 1988, advanced turboprop systems research will emphasize source noise, cabin environment, turboprop installation aerodynamics, and the development of advanced aerodynamic and structural analysis techniques for both single- and counter-rotation propellers. Advanced high-temperature engine materials research will develop fundamental technology to enable very high thrust-to-weight (20 to 1) gas turbine engines with durable, long-life hot section components.

Numerical Aerodynamic Simulation

The Numerical Aerodynamic Simulation (NAS) program objective is to significantly augment the native's capabilities in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical simulation of aerodynamic flows. This program will provide the computational capabilities required to obtain solutions to problems which are currently intractable. Ongoing research and technology base efforts in computational aerodynamics will benefit significantly from the advanced computational capabilities to be provided by the NAS program.

Fiscal year 1988 will be an important year in the development of the NAS system. The second high-speed processor (HSP-2), which will be four to six times more powerful than HSP-1, will be installed and integrated into the NAS system. NAS operations support funding has been consolidated in the NAS program from the Research and Technology Base. This consolidation of funding simplifies management and reporting of NAS progress.

Aeronautics Research and Technology—Committee Comments

The Committee authorizes $375 million for Aeronautics Research and Technology in fiscal year 1988. This is the same as the President's budget request.

In 1987, the Aeronautical Policy Review Committee issued its second report entitled "National Aeronautical R&D Goals, Agenda for Achievement." This report recognized the considerable importance the aeronautics sector has to the balance of trade and to the overall competitive position of the United States in world markets, a position that is strongly endorsed by this Committee. The aerospace trade surplus in 1986 was almost $12 billion, but there are signs that this sector of the economy is facing serious and sustained threats from other nations, such as Japan, the European Economic Community (EEC),Brazil, Indonesia, and others. The report states, for example, that in 1986, for the first time in our history, high technology imports exceeded exports.

The Committee has long recognized the relationship between NASA's aeronautics research and development program and our national economic and defense security. The United States has long been the world leader in aeronautical technology development, and we must maintain this lead. To do so, we must continue the suc-

cessful government-industry partnership that has successfully identified the opportunities, provided the advanced technologies, and made possible the industry we enjoy today. In that same tradition, it is expected that the studies on long-distance, high-speed transports, recently initiated by NASA with the aeronautics industry, may confirm this area as one of the most important unexploited opportunities for leadership in world civil aviation markets at the turn of the century and beyond. These studies should be applauded and supported because they could lay a foundation upon which the United States establishes new technological and market leadership.

The recent history of funding for the aeronautics R&D program has not reflected the full importance of the program. Overall, funding for aeronautics research and development has declined 25 percent in the last decade. This trend is disturbing, since this program offers a tremendous economic benefit to this country. The two major categories of funding within the area, the Research and Technology Base and the Systems Technology program reveal an even more unsettling narrowing of emphasis in aeronautics. The R&T Base, which funds the research and innovations that produce new concepts and designs is at an adequate level—the important basic seed work is being done. The Systems Technology programs, however, have been reduced 70 percent in the same time period. It is this category of programs which identify the concepts from the R&T programs and, in cooperation with industry, take the first step along the path to transform these concepts into commerically viable applications. These programs, which are generally high risk in nature and the most costly part of the R&T chain because they often require large-scale hardware, ensure that the products of the basic R&T programs at NASA don't simply end up on the shelf somewhere, but are introduced into the commerical markets to help keep our industry a world leader.

In preparation of its fiscal year 1989 budget request, the Committee requests that NASA review these perceived trends in the Systems Technology programs and initiate corrective measures. At the same time, NASA is directed to prepare a multi-year technology development validation plan that will help the United States retain its leadership in aeronautics research and technology and compete in the international marketplace for future civil aircraft. This plan shall be prepared in cooperation with private industry and shall be designed to assure continued U.S. leadership in future civil aircraft markets. This Plan should be submitted to the committee by March 1, 1988.

G. Transatmospheric Research and Technology—$66,000,000

The Committee authorizes $66,000,000 for Transatmospheric Research and Technology for fiscal year 1988. This is the same as the President's budget request.

The National Aerospace Plane (NASP) program is a joint effort between NASA and the Department of Defense to accelerate the development of critical enabling techologies for this revolutionary class of hypersonic/transatmospheric vehicles. Such vehicles could be capable of taking off from and landing on conventional runways,

using airbreathing propulsion up to, or near, orbital speed, and providing rapid and low-cost access to space.

For fiscal year 1988, ongoing activities in the National Aerospace Plane program include technology development in subsonic, supersonic, and hypersonic hydrogen-fueled propulsion technology; advanced high-temperature materials and lightweight, high-strength, thermal structural concepts; and computational fluid dynamics, which remain the three critical technologies for all transatmospheric vehicle applications. The engine and airframe contracted efforts will be supported by an extensive focused technology effort at NASA centers (Ames, Langley and Lewis) and other government laboratories. Work will continue on development of, and manufacturing technology for, lightweight, high-temperature advanced materials. For example, processing techniques for fabricating ceramic matrix composite panels will be demonstrated. Tests will be conducted on subscale component integration models of scramjet concepts over the speed range of Mach 3.5 to Mach 8.

Transatmospheric Research and Technology—Committee Comments

The National Aerospace Plane program continues to represent an important opportunity for revolutionary advances in U.S. aeronautical and space capabilities. The most significant technological barriers to the successful completion of the NASP program—airbreathing propulsion, structures and materials, and aerodynamic computational methods—will require many years of sustained effort and support if they are to lead to the development of a prototype and eventually an operational vehicle. While the Committee is fully aware of the fact that national security missions are the most likely, early applications of this joint NASA/DOD program, in the long term the NASP offers the promise of enhancing our competitive position in several major areas of aeronautical research and development. With the technology base that emerges from this program, the United States should be able to meet the competition that we face in this area from the Soviet Union, Japan, ESA and others.

Recognizing the value of this fundamental research and development program, the Committee authorizes the Administration's full request of $66 million in fiscal year 1988 for the NASA portion of the program.

H. Space Research and Technology—$212,000,000

The Committee authorizes $212,000,000 for fiscal year 1988 for Space Research and Technology. This is $38,000,000 less than the President's budget request. However, pursuant to the approach taken in H.R. 1827 (S. Report 100-48), the fiscal year 1987 Supplemental Appropriations Bill, for the development of an Advanced Launch System, the Committee assumes that NASA will be reimbursed by DOD to carry out the propulsion technologies activities associated with the Committee reduction.

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Summary of funding for fiscal year 1988

Research and technology base	$115,900,000
Systems technology programs	0
Civil Space Technology Initiative (CSTI) Program	96,100,000
Total Space Research and Technology	212,000,000

The goal of the space research and technology program is to retain national preeminence in space by advancing the technology base that supports the civil space program. The specific objectives are to provide a broad base of advanced technology for vehicle and subsystem concepts, components, devices and software; to develop the underlying analyses methods, materials behavior, and discipline technologies; and to perform ground and in-space experiments to provide basic data and verify concepts so that new technology can be utilized with confidence.

1. RESEARCH AND TECHNOLOGY BASE—$115,900,000

The Committee authorizes $115,900,000 for fiscal year 1988 for Research and Technology Base. This is the same as the President's budget request.

Summary of funding for fiscal year 1988

Aerothermodynamics research and technology	$11,100,000
Space energy conversion research and technology	14,600,000
Propulsion research and technology	14,500,000
Materials and structures research and technology	17,900,000
Space data and communications research and technology	8,900,000
Information sciences research and technology	8,000,000
Controls and guidance research and technology	6,300,000
Human factors research and technology	4,900,000
Space flight research and technology	23,200,000
Systems analysis	6,500,000
Total Research and Technology Base	115,900,000

Aerothermodynamics research and technology

Future aerospace vehicles, such as aeroassisted orbital transfer vehicles (AOTV), aerospace planes, and hypersonic cruise and maneuver vehicles, must be capable of hypervelocity flight in the atmosphere—ranging from the rarefied to the continuum flow regimes.

In fiscal year 1988 continued emphasis will be placed on developing computer codes capable of simulating external flows relevant to aerospace transportation systems and on providing analysis and design capability to predict aerodynamic and aerothermodynamic loads.

Space energy conversion research and technology

The objectives of this program are to explore concepts and components to improve the performance, lifetime, and cost effectiveness and to reduce the size and weight of power and life support systems for large manned space systems, small earth-orbiting and planetary exploration spacecraft, and other ambitious future space missions.

In fiscal year 1988, a system program in high-capacity nuclear power will be established as part of the new CSTI program. Nuclear technologies needed to meet the high-capacity power systems requirements for evolutionary space station(s), lunar and planetary

bases, and for high-power demand electric propulsion systems will be developed in this program.

Propulsion research and technology

The objective of the propulsion research and technology program is to establish a base of design concepts and analytical tools that will allow the design and development of advanced propulsion systems with the known performance, life, and operational characteristics essential for next generation space transportation systems.

In fiscal year 1988, fundamental efforts in reusable engine research and technology, which are aimed at establishing the technology base for component life extension and prediction, will continue in the research and technology base program.

Materials and structures research and technology

The objective of the materials and structures program is to provide technology that will allow the development of future spacecraft, large-area space structures, and advanced space transportation systems with significant improvements in performance, efficiency, durability, and economy.

In fiscal year 1988, the materials program will continue to focus on the effect of the space environment on structural materials for spacecraft, large-area space structures, advanced space transportation systems, and orbital transfer vehicles.

Space data and communications research and technology

The space data and communications research and technology program is directed toward developing the advanced ability to control, process, store, manipulate, and communicate space-derived mission data and enabling new communications concepts.

In fiscal year 1988, the space data research and technology program will emphasize general purpose, fault-tolerant computing. All space communications research and technology will remain in this research and technology base program.

Information sciences research and technology

The objectives of the information sciences research and technology program are to discover advanced concepts, techniques, and system algorithms and to invent system architectures, hardware devices and components, and software in order to enable viable and productive space information systems.

In fiscal year 1988, technologies needed to meet the science sensor requirements of the Earth Observing System and Large Deployable Refractor will be developed in this program.

Controls and guidance research and technology

The controls and guidance research and technology program goals are to generate the practical design methods and techniques requried to enable precise pointing and stabilization for future NASA spacecraft and payloads.

In fiscal year 1988, this activity will continue theoretical exploration of modern control theory methods associated with both system identification and distributed and adaptive control.

Human factors research and technology

The objective of the space human factors research and technology program is to provide the technology base for productivity, efficiency, and safety in increasingly complex manned space operations, including the space station and a potential National Aerospace Plane.

In fiscal year 1988, work stations for proximity operations will be evaluated. The virtual work station will undergo hardware integration and display upgrade.

Space flight research and technology

The objective of this program is to provide research-quality flight data supportive of ground-based research and technology efforts for the development and operation of future space systems. This objective is accomplished through the utilization of current and future space facilities such as in-space research laboratories.

In fiscal year 1988, under the orbiter experiments program, key aerodynamic, aerothermodynamic, and thermal protection system experiments may resume flights for completion of the previously planned six-flight series for these experiments.

System analysis

One of the primary objectives of the systems analysis program is to conduct systems analyses to identify technology requirements for spacecraft systems, space transportation systems, and large space systems for the national space program and integrate these requirements into a comprehensive technology plan.

In fiscal year 1988, the Mars rover studies will be completed; emphasis will be redirected toward an outer planet science station study; and astrophysics activities will center on the technology requirements for interferometric observatories across a range of wavelengths.

2. CIVIL SPACE TECHNOLOGY INITIATIVE (CSTI) PROGRAM—$96,100,000

The Committee authorizes $96,100,000 for fiscal year 1988 for Civil Space Technology Initiative (CSTI) program. This is $38,000,000 less than the President's budget request. The reduction results from the assumption that NASA will be reimbursed for propulsion technology activities by DOD.

Summary of funding for fiscal year 1988

Propulsion	$1,200,000
Vehicle	15,000,000
Information	17,400,000
Large structures and control	22,800,000
Power	14,000,000
Automation and robotics	25,700,000
Total CSTI	96,100,000

Many of these activities have been transferred from previous Space Research and Technology Activities and augmented in the CSTI program.

Propulsion

The objective of the CSTI propulsion program is to develop and demonstrate main engine and booster propulsion technology which will enable the development of the next generation of earth-to-orbit vehicle.

In fiscal year 1988, the CSTI propulsion program will include earth-to-orbit technology for both LOX/hydrogen and LOX/hydrocarbon propulsion systems.

Vehicle

The aeroassist flight experiment (AFE) will investigate the critical vehicle design and environmental technologies applicable to the design of an aeroassisted orbital transfer vehicle (AOTV).

In fiscal year 1988, development of the AFE will be initiated.

Information

The objective of the information systems technology program is to discover and develop new materials, devices, and components in order to enable viable and productive detection, imaging, and storage systems for future space and planetary missions in the next century.

In fiscal year 1988, onboard computing and optical disk memory technology elements of the space data and communications program have been incorporated into the CSTI program to focus on the high-rate/capacity data requirements of future NASA missions.

Large structures and control

The objective of the large structures and control program is to provide experimental validation of analytical methods for predicting coupled structural dynamics and controls response for multibody space structures with special emphasis on the control of flexible structures (COFS) program.

In fiscal year 1988, ground-based elements initiated earlier will be continued for the COFS I and II structures.

Power

The objective of this program is to develop the technology needed to meet the high-capacity power systems requirements for evolutionary space station, lunar and planetary bases.

In fiscal year 1988, an aggressive dynamic conversion systems technology development and verification program will be initiated.

Automation and robotics

The objective of the automation and robotics program is to exploit the potential of artificial intelligence and telerobotics to increase the capability, flexibility, and safety of space and ground operations while decreasing associated costs.

In fiscal year 1988, the initial demonstration will be of a two-armed remote manipulator for satellite module replacement and fluid transfer tasks.

Space Research and Technology—Committee Comments

The Committee authorizes $212 million for Space Research and Technology for fiscal year 1988. This is $38 million less than the President's budget request. The Committee's reduction is made without prejudice to the Civilian Space Technology Initiative (CSTI), an initiative strongly endorsed and prescribed by the Committee.

The Committee strongly supports an enhanced level of activity in the NASA Space Research and Technology Program as evidenced in the fiscal year 1987 NASA authorization bill that earmarked an additional $20 million for advanced technology development toward next generation launch systems that would provide low-cost, reliable access to low-earth and geosynchronous orbits.

Despite the Committee's strong support for Space Research and Technology, the initiation of the Advanced Launch System (ALS) in conjuction with the submission of the President's fiscal year 1988 budget request has raised the possibility that duplication may exist between the ALS and CSTI propulsion proposals, both of which emerged from the ongoing National Space Transportation Architecture Study. In light of this situation, the Committee has reduced the fiscal year 1988 level of activity in accordance with the assumed reimbursement of NASA by DOD for these particular propulsion activities (H.R. 1827, S. Report 100-48).

The Committee assumes that this duplication will not appear in the fiscal year 1989 budget request and that any future DOD reimbursements to NASA will be in addition to the base CSTI program. The Committee also anticipates that NASA will initiate additional civilian space technology initiatives in the fiscal year 1989 budget submission, including propulsion technologies for space systems other than the ALS.

The Committee feels strongly that the National Commission on Space identified a serious deficiency in the Nation's space program when it recommeneded that the United States substantially increase its investment in the space technology base—the Commission recommended a threefold growth in NASA/s base technology budget. The Committee is committed to correcting this deficiency and continues to strongly support space research and technology activities, in particular the Civilian Space Technology Initiative.

I. Safety, Reliability and Quality Assurance—$16,200,000

The Committee authorizes $16,200,000 for fiscal year 1988 for safety, reliability and quality assurance. This is the same as the President's budget request.

The objective of the Safety, Reliability and Quality Assurance (SR&QA) program, formerly the Standards and Practices Program, is to support NASA's goals through activities in safety, productivity, reliability and quality assurance, maintainability, software assurance, systems engineering, and program practices which reduce program risk; to improve product confidence; and to encourage good program procedures in the technical execution of NASA programs.

In fiscal year 1988, the SR&QA program will continue to conduct activities in support of the objectives of the agency. The increase in

funding from the fiscal year 1987 level reflects an increase in safety related activities and the creation of a Technical Assessment Program. The Technical Assessment Program will develop systems that monitor the status of equipment; validate technical designs; report and analyze problems; analyze trends; and judge system acceptability in agency-wide programs.

The Technical Assessment Program will address the reporting and documentation of problems, problem resolution and trends, and other safety systems as required. One component of the assessment program is a computerized, real-time, agency-wide problem reporting and corrective action system which will allow an assessment of SR&QA problems. As currently planned, the system will contain data on failures, nonconformance anomalies, and unsatisfactory conditions for problems analysis and resolution, remedial and preventive actions, and trend analysis for flight and critical ground hardware, as well as certain generic program hardware. The information resulting from the system will be used to design, flight, and test reviews. It will be specifically designed to provide a board data base which will be accessible by NASA and its contractors on an iterative basis. It will provide a means whereby effective trend analysis can be accomplished, thus providing early and more complete illumination of problems to management.

Efforts are being planned that will revitalize the basic NASA safety program. Major activities will be focused on increasing the safety of high hazard operations, better understanding the failure modes of highly stressed wind tunnel components and pressure systems, and quantifying the hazard potential of new, exotic propellants, existing cryogenic propellants, and new composite materials. The existing effort to automate mishap reporting will be expanded to include the capability for trend analysis and generation of multimedia, generic lessons learned from the central data base. Critical policies, procedures, practices, regulations, guidelines, and directives will be reviewed and revised, or developed, as appropriate. Risk assessment of hazards identified in NASA activities will be conducted to determine the implied risks to people and property.

Safety, Reliability and Quality Assurance—Committee Comments

The Committee authorizes $16.2 million for Safety, Reliability and Quality Assurance for fiscal year 1988. This is the same as the President's budget request.

The Committee remains strongly committed to the restoration of NASA's Safety, Reliability and Quality Assurance (SR&QA) programs as the hallmarks of the agency. The inclusion of a separate line item in the fiscal year 1988 NASA Research and Development budget request for SR&QA helps to identify the level of effort, but the budget justification does not provide adequate supporting documentation. The Committee is hopeful that this situation will be corrected in the fiscal year 1989 NASA budget submission.

As an indication of the Committee's support of the SR&QA program, the Committee has approved 99 additional slots for these activities in the Research and Program Management account. Thirty-three of these slots will be located at NASA Headquarters, and sixty-six of the slots will be at the NASA field centers. These addi-

tional persons should greatly increase NASA's internal capabilities and reduce the need to contract out for SR&QA services.

The Committee must note its dissatisfaction with the "process" and the "personnel" involved in the Atlas/Centaur Fltsatcom launch which failed on March 26, 1987. Regrettably, this launch failed to meet all existing launch commit criteria and, in some regards, a reasonable standard of care. The Committee sees the failure of NASA and the SR&QA Office to reassess the expendable launch vehicle launch commit criteria and the associated launch process as a grievous error of judgment. There was no excuse for the Atlas-Centaur failure, and the failure of NASA to realize that the lessons learned from the *Challenger* tragedy were also applicable to other NASA programs is incomprehensible.

The Committee, therefore, instructs the Office of Safety, Reliability and Quality Assurance to include as part of its fiscal year 1989 budget justification, a detailed accounting of the systems and processes currently under review or proposed for review by the Office. The Committee expects SR&QA to be the hallmark of NASA's manned and unmanned space activities, and it will continue to work with the Office of SR&QA to ensure the reestablishment of this standard.

J. Tracking and Data Advanced Systems—$18,100,000

The Committee authorizes $18,100,000 for Tracking and Data Advanced Systems fiscal year 1988. This is the same as the President's budget request.

The objective of the Advanced Systems Program is to perform studies and provide for the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data handling capabilities that will meet the needs of approved new missions and near-term new starts; and (2) improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

Activities planned for fiscal year 1988 include efforts to obtain location accuracies within the one meter level for Earth-orbiting spacecraft which would make possible a new class of high precision Earth observatory missions on the Shuttle, Space Station and on free flying spacecraft; studies on ground based navigation strategies, analyses and demonstrations for Galileo, Uylsses, and Mars Observer; efforts to improve communications between the ground and spacecraft; and investigations on achieving more efficient operation of the mission control facilities and providing for the necessary real time interaction between the spacecraft experimenters and their experiments.

Tracking and Data Advanced Systems—Committee Comments

The Committee authorizes $18.1 million for Tracking and Data Systems for fiscal year 1988, which is the same as the President's budget request.

The Committee continues to strongly support these activities that will improve the cost effectiveness and reliability of the total mix of spaceflight missions.

II.—SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS—$4,081,300,000

The Committee authorizes $4,081,300,000 for fiscal year 1988 for Space Flight, Control and Data Communications. This is $17 million more than the President's budget request.

The objective of the NASA program of space flight, control and data communications is to provide for the operational activities of the Space Transportation System and tracking and communication system support to all NASA flight projects. This objective is achieved through the following elements:

Shuttle Production and Operational Capability.—A program to provide a fully capable fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, initial spares, production tooling, and related supporting activities.

Space Transportation Operations.—A program to provide the standard operational support services for the Space Shuttle and the expendable launch vehicles. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

Space and Ground Network, Communications and Data Systems.—A program to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects. This support is currently provided by a worldwide network of NASA electronic ground stations interconnected by a communications system using ground, undersea, and satellite circuits. The Tracking and Data Relay Satellite System (TDRSS) will become the primary system for supporting upcoming Earth orbiting missions.

Summary of fiscal year 1988 funding levels

Shuttle production and operational capability	$1,150,600,000
Space transportation operations	1,885,800,000
Space and ground networks, communication and data systems	944,900,000
Expendable launch vehicle operations	100,000,000
Total space flight, control, and data communications	4,081,300,000

The primary program objective of current activity in the Space Transportation System is to complete the safe return to Space Shuttle flight activities. The Space Shuttle is the key element of a versatile Space Transportation System (STS) that is available to a wide variety of national users and certain international users. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space apparatus, spacecraft scientific experiments, and national security payloads. In addition to transporting materials, equipment and spacecraft to orbit, the Shuttle offers unique capabilities that cannot be achieved with expendable launch vehicles (ELV)—to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; and to perform rescue missions.

Shuttle Production and Operational Capability provides for the national fleet of Shuttle orbiters including the replacement orbiter

which is fully funded in fiscal year 1987. Funding also provides for the launch site facilities, initial spares, production tooling, and related supporting activities. This line item also includes the design, test, analysis and certification associated with the recovery actions necessary, as a result of the *Challenger* accident to verify the flight hardware and mission support processes necessary for return to flight.

Shuttle Operations provides the standard operational support services for the Space Shuttle. Within Shuttle Operations, flight hardware is produced, refurbished and repaired; and manpower, propellants, and other materials are furnished to conduct and support both flight and ground operations. The Shuttle Operations program provides for the launch of NASA missions, DOD, other U.S. government and certain commercial and international missions on a reimbursable basis. The launch schedule calls for 3 flights in 88 (the first launch after the *Challenger* accident is scheduled for June 1988), and 7 flights in 1989. However, pending NASA decisions and the results of the solid rocket motor test program, this schedule could change.

The ELV program is currently totally funded through reimbursements from users. Privatization of these systems continues to be actively pursued. The only planned NASA launch at this time is for the Cosmic Background Explorer spacecraft which will utilize a Delta launch vehicle acquired with reimbursements for replacement of residual assets.

The purpose of the Space Ground Networks, Communications, and Data Systems program is to provide vital tracking, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of the DOD, other government agencies, commercial firms, and other countries and international organizations engaged in space research.

Support is provided for Earth orbital, planetary and solar system exploration missions, research aircraft, sounding rockets and balloons. Included in Earth orbital support are the Space Shuttle Spacelabs and scientific and applications missions.

Tracking and acquisition of data for the spaceflight projects presently accomplished through the use of a worldwide network of NASA ground stations and by the first of a system of three tracking and data relay satellites in geosynchromous orbit working with a single highly specialized ground station. Ground facilities are interconnected by terrestrial and communications satellite circuits which tie together the spacecraft and control centers for control of the missions.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN) which supports Earth orbital missions; the Deep Space Network (DSN) which primarily supports planetary and interplanetary flight missions; and the Space Network including the Tracking and Data Relay Satellite System (TDRSS) which will provide all low Earth orbital mission support when it becomes fully operational.

A. Shuttle Production and Operational Capability—$1,150,600,000

The Committee authorizes $1,150,600,000 for fiscal year 1988 for Shuttle Production and operational Capability. This is $79 million less than the President's budget request.

Summary of fiscal year 1988 funding levels

Orbiter operational capability	$324,200,000
Launch and mission support	249,300,000
Propulsion systems	552,100,000
Changes and systems upgrading	25,000,000
Total shuttle upgrading and operational capability	1,150,600,000

Orbiter operational capability

With the recent loss of *Challenger* (OV–099), our primary objective is to return the three orbiter fleet to safe flight in fiscal year 1988. This will provide safe and reliable access to space for NASA, the Department of Defense and certain domestic and international users of space. In support of this objective, orbiter production activities include the necessary safety modifications identified by the Rogers Commission and the post-*Challenger* accident review process and the development and installation of necessary hardware, software and procedural modifications. Also, work continues on improvements to achieve greater operational capabilities, reduce operational costs, and meet system requirements.

The structural spares program initiated in fiscal year 1983 provided the foundation for a production of a replacement orbiter with a delivery date planned for mid-1991. A new set of structural spares was proposed by the Administration in fiscal year 1988 in order to sustain the capability to *produce another vehicle*, in addition to providing additional spares for inventory. Pending further review of the Nation's space transportation requirements and the role expendable launch vehicles will play in that system, the Committee has deferred initiation of this program in fiscal year 1988.

The procurement and fabrication of the orbiter spares inventory is ongoing. A concerted effort has been made to better define the spares requirements and production capability at various vendors. A study is under way to determine logistics depot and maintenance requirements.

In fiscal year 1988, orbiter funds provide for the procurement of a logistics capability including establishing an inventory of spares to support operations requirements, the continuation of previously approved systems improvement programs, necessary safety modifications identified as a result of the *Challenger* accident review process, completing the existing set of structural spares to support the production of a replacement orbiter, and the engineering analysis and integration support for the increasing flight rate. Orbiter funding also provides for orbiter support activities such as the remote manipulator system, the on-board flight software, and potential implementation of a crew escape system during orbiter controlled gliding flight.

Launch mission support

This activity supports the development of launch and mission support capabilities, principally at the Johnson Space Center (JSC) and Kennedy Space Center (KSC). This budget contains funding required to conduct the necessary modifications to the KSC ground support equipment to return to flight status, such as improving the external tank hydrogen vent system on the launch pad, installation of debris traps in the main propulsion system propellant lines and new support equipment for the redesigned solid rocket boosters.

Funding has been included for additional landing aids and runway end barriers for the current, and one additional, contingency/abort landing site. Capability improvements have been added for weather prediction and information handling to improving system monitoring, notably for anomaly tracking. A shift in priority in the ground systems replacement/refurbishment program, consistent with the Rogers Commission recommendations, has delayed improvements to the Mission Control Center and accelerated improvements in the simulation training facility including new host computers and associated interface controllers. Funding also is included for a "kit" to allow the modification of a Boeing 747 into a (second) Shuttle Carrier Aircraft (SCA), thus reducing the potential downtime impact of this major single point of failure.

In fiscal year 1988, the launch site equipment activity includes finalizing the return-to-flight status modifications in the KSC ground support equipment associated with the vehicle and launch processing facilities. Activities are also under way to improve the capability to support the flight rate requirements at KSC.

Mission operations capability funding in fiscal year 1988 provides for completion of replacement of the host computers and selected critical items for the Shuttle training simulators. Fiscal year 1988 is the initial year in the efforts to procure a fourth Shuttle Training Aircraft (STA), to re-engine the Shuttle Carrier Aircraft (SCA) and to replace ADP and other hardware in the Software Production facility. Continuing projects include the procurement of the Shuttle Carrier Aircraft (SCA) mod kit and improvements to weather prediction, information handling, and mission control systems.

Propulsion Systems

Propulsion Systems provide for the production of the Space Shuttle main engines (SSME), the implementation of the capability to support operational requirements, and anomaly resolution for the SSME, solid rocket booster (SRB), and external tank (ET). The SSME program includes the production of the main engines required for the orbiter fleet, the procurement of spares, ground testing operations, development and certification activities to improve operating margins, reliability and durability, and anomaly resolution capability. The SRB program includes a major redesign, development and qualification effort for the solid rocket motors to improve safety margin and correct the deficiencies that led to the *Challenger* accident. The SRB program also includes a thorough reevaluation of the booster hardware, redesign of the hardware for reusability and operational cost reductions, and procurement of

manufacturing tooling and equipment to support the projected flight rate. In the ET program, the objectives are to support recovery activities and the return to safe flight. Systems support primarily provides for the testing of the SSME in the main propulsion test article configuration.

The solid rocket booster (SRB) funding requirements support the redesign and requalification efforts necessary as a result of the Challenger accident. Based upon the investigation results of the failure and the actions recommended by the Rogers Commission, a complete reassessment of the certification program on all hardware and a redesign of the solid rocket motor joint configurations are under way. In-depth reviews of the systems failure mode and effects analysis (FMEA), operational procedures and the design of critical hardware on the critical items list (CIL) is being conducted and changes will be implemented as necessary. Extensive testing will be conducted of all design alternatives under conditions that accurately simulate the launch environment to insure that the final design meets the program safety and performance requirements. A second SRM static firing test stand is being provided to assure the capability to initiate the flight program in fiscal year 1988. All necessary hardware replacement on refurbishments will be procured to support resumption of flight activities and the planned build-up in flight rate. Funding is also included for alternative source procurement studies for the advanced solid rocket motor (ASRM). The filament wound case (FWC) program is being deferred as a result of the extensive changes being considered in the basic SRB program and the Air Force's decision to defer activation of the Vandenberg launch site. FWC funding is provided through completion of the structural test program.

In systems support, capability is being maintained for the full power level test of three clustered engines in the National Space Technology Laboratory (NSTL) main propulsion test stand in early 1989. This test will provide for a verification of the main propulsion system operations at full power level using the main propulsion system test hardware mounted in the aft end of the simulated orbiter.

The funding request for the fiscal year 1988 budget is based upon resumption of the flight program in February 1988—a date that was recently slipped to June 1988—and the design, test, and certification of the propulsion hardware for flight. A complete reassessment of the program is included. It consists of a thorough review of the FMEA/CILs and recertification of all flight hardware to assure compliance with flight requirements. The SSME program will continue production of flight hardware and the development programs including necessary improvements to the current configuration and the alternate turbopump programs. The SRB program will complete the redesign of the solid rocket motors and be re-certified prior to the first flight. The external tank program will complete the FMEA/CIL reviews and continue the efforts to develop processing improvements to reduce the cost of manufacturing tanks, the continued installation of rate tooling to support the future flight rates and overhaul of the barges used to transport finished tanks from Michoud to the launch sites.

Changes and Systems Upgrading

The Changes and Systems Upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the program element budget estimates. Such funds are necessary to provide for programmatic and technical changes, such as modifications to the flight hardware to improve systems reliability, safety and performance; changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

The funding requested for fiscal year 1988 will provide for those changes which are considered to have the highest priority. The objectives are to improve reliability, increase operating safety margins and efficiency, and reduce costs.

Space Shuttle Production and Operational Capability—Committee Comments

Restoring the Space Transportation system to flight readiness is the highest priority for NASA in fiscal year 1988. Therefore, the Committee has authorized $1,150.6 million for Space Shuttle Production and Operational Capability for fiscal year 1988. In addition, in Section 111, the Committee has authorized "such sums as may be necessary" for the Administrator to take the necessary steps to return safely the space shuttle fleet to flight status. These monies are authorized in anticipation of a fiscal year 1988 NASA Budget Amendment for additional anomaly resolution activities and Rogers Commission recommendations.

The only change made to the Space Shuttle Production and Operational Capability budget request by the Committee was the deletion of $79 million of funding for the structural spares program. This decision was based on the fact that until there is a final determination as to how and what mix of expendable launch vehicles, including an Advanced Launch System, will be used to meet the Nation's space transportation requirements, funding of structural spares would be premature. The Committee is well aware of the original intent of the structural spares program and recognizes the value of the existing structural spares to the construction of a new orbiter. However, at this time, the Committee does not feel that funding for this initiative is warranted in fiscal year 1988.

The most immediate concern to the Committee is the restoration of the space shuttle fleet to flight status. Successful implementation and verification of the proposed anomaly resolution activities and Rogers Commission recommendations are the critical elements of this area of the program.

In general, the Committee is pleased with NASA's effort in this regard. However, the Committee agrees with the National Research Council Panel for the Technical Evaluation of the Redesign of the Space Shuttle Solid Rocket Booster that the real barometer of the success of the anomaly resolution program will be the outcome of the proposed test program. Since the first full-scale test is not scheduled until August 1987, it is still premature for the Committee to comment on these activities.

The Committee remains convinced that NASA should fully involve the solid rocket motor industry in the solid rocket motor redesign and test activities. However, the Committee is still uncertain that NASA is pursuing this matter as virogously as the Committee desired. Restoration of the space shuttle fleet to flight status is a national priority, and no available resource should be overlooked or underutilized in this effort. The Committee expects that NASA fully understands the Committee's position on this matter.

Meanwhile, the Committee intends to closely review anomaly resolution activities and implementation of the Rogers Commission's recommendations. An oversight hearing to look at these and other related issues will be conducted during this summer. The Committee also intends to review closely the fiscal year 1988 budget amendment for anomaly resolution activities and to provide funds for critical activities related to the safe return of the shuttle to flight status.

Despite the fact the Committee is anxious to see the space shuttle return to flight, the Committee recognizes the need for the Administrator's recent decision to slip the flight date from February until June 1988. The conduct of a "wet" countdown test and a Flight Readiness Firing Test is a prudent decision that should help hone the skills of the launch team.

The Committee looks forward to the receipt of a new manifest as soon as possible and hopes the proposed delay wil not have an adverse impact on major space science payloads. The Committee also supports the more by NASA toward more realistic flight rates for 1988 and 1989.

For the mid-term, the critical issue is the successful implementation of an Advanced Solid Rocket Motor (ASRM) program. The Committee is pleased that NASA submitted an ASRM program to the Committee on March 31, 1987 and that a Request for Proposals for Phase B studies was released on May 29. However, the Committee will reserve its final judgment on the proposal until after it has conducted an oversight hearing. In general, the Committee feels that an ASRM program that provides added reliability and performance, with the emphasis on the former and not the latter, is a step in the right direction. The Committee also feels strongly that NASA cannot depend upon the redesigned solid rocket motor, a technical fix to a design flaw, for the long-run. However, the Committee does have concerns about the proposed extension of the current contract and the proposal for a government-owned, contractor-operated facility to manufacture the ASRM.

Based on the Committee's review of the available data, it does not believe the Second Sourcing of the redesigned motor is now warranted. The emphasis should be directed to an Advanced Solid Rocket Motor as has been properly done by NASA.

For the long-term, the Nation must begin to make some decisions about the space transportation network of the future. The space shuttle fleet has a limited life expectancy and will need to be replaced. New generations of expendable launch vehicles will need to be developed that dramatically reduce the cost of transportation. The dilemma confronted by the Committee is that it is trying to restore the existing space transportation infrastructure, while simultaneously trying to lay the foundation for the future. Unfortu-

nately, a clear set of requirements has not yet been made available to the Committee in terms of the future space transportation requirements. The Committee requests that NASA and DOD provide such a set of requirements to assist in its determination and strongly suggests that the final National Space Transportation Architecture Study be released to the appropriate Congressional Committees.

B. Space Transportation Operations—$1,885,800,000

The Committee authorizes $1,885,800,000 for fiscal year 1988 for Space Transportation Operations.

Summary of fiscal year 1988 funding

Flight Operations	$561,100,000
Flight Hardware	923,100,000
Launch and Landing Operations	401,600,000
Total Space Transportation Operations	1,885,800,000

Funding for Shuttle Operations is normally combined with the reimbursements for Shuttle launch services received from other U.S. government, commercial, and international users to support the launch and flight operations requirements of the Space Shuttle. However, in fiscal year 1988 there are no anticipated reimbursables due to policy changes and the grounding of the space shuttle fleet.

The Flight Operations activity is divided into three major elements: mission support, integration, and support. Mission support includes training, flight operations activities and a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Integration includes launch support services and sustaining engineering for orbiter systems, cargo analytical integration, and systems integration. The support element includes base operational support at JSC and systems support activity at JSC, Headquarters, and the Goddard Space Flight Center.

The Flight Hardware program element provides for: the procurement of external tanks (ET), solid rocket motors, booster hardware, and propellants; spare components for the Space Shuttle Main Engine (SSME); orbiter spares; ET disconnects, logistics support for the ET, SRB, and SSME flight hardware elements; and maintenance and operations of flight crew equipment.

Launch and Landing Operations provides for the pre-launch preparation, launch, and landing operations of the Shuttle and its cargo. Also, liquid propellants used in launch operations are provided for in this budget.

There are currently no planned reimbursable funds for Shuttle Operations in either fiscal year 1987 or 1988. It is anticipated that reimbursable funding will resume in the future as the shuttle flight rate builds up.

The Expandable Launch Vehicle (ELV) program provides for the procurement of expendable launch vehicles and launch support services. The only planned NASA launch is for the COBE spacecraft which will utilize a Delta launch vehicle made available by

using reimbursements for residual vehicle hardware made available to other users.

Flight Operations

The Flight Operations portion of the Shuttle Operations budget continues to support that activity predominately associated with the effort at JSC to plan for and conduct the on-orbit portion of STS missions from launch to landing. The functions are essentially the same as in the past: maintain and operate all the ground facilities necessary for flight preparation and execution, and to instruct the flight and ground controller crews; maintenance and operation of proficiency, training and orbiter ferry aircraft and to perform analyses and operation of the mission planning necessary to conduct and control each mission. It also includes the sustaining engineering required to integrate all flight and ground elements and to assure systems safety and integrity; the analytical integration of the payloads into the orbiter and the planning to assure compatibility and verification of interfaces; and support of crew operations and training programs. Orbiter engineering manpower continues the required support of procedure and hardware modifications resulting from the FMEA/CIL reviews in addition to the sustaining engineering activities that ensure maintainability, reliability, and anomaly resolution during operations.

Flight Hardware

The Flight Hardware program element provides for the procurement of external tank (ET), the manufacturing and refurbishment of solid rocket booster (SRB) hardware and motors, spare components for the main engine (SSME); orbiter spares including ET disconnects, sustaining engineering and logistics support for ET/SRB/main engine flight hardware elements; and maintenance and operation of flight crew equipment.

In fiscal year 1988 requirements for orbiter flight spares, crew equipment spares, and logistics are based on estimates that consider projected flight rates, maintenance schedules, operational hours, turnaround times, and lead times to procure or repair flight hardware. The budget provides replenishment line and shop replaceable units, as well as the manpower to support the overhaul and repair activity for the orbiter, extravehicular maneuvering unit and other crew equipment. The flight equipment processing contract (FEPC) which was initiated during fiscal year 1986 is continuing its build-up to full capability to support the projected flight rates. Main engine hardware provides for manufacturing and delivery of overhauled engines, engine component spares and flight support. Flight hardware requirements activity for the SRB and ET include the procurement of the materials and labor required for refurbishment and fabrication of units which will be flown during fiscal year 1988, as well as the support of the production of units which will be flown thereafter.

Launch and Landing Operations

Launch and Landing Operations provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the ground processing facili-

ties at KSC. These services are primarily provided by means of three separate operations contracts.

Operation of the launch and landing facilities and equipment at KSC is the primary function of the Shuttle Processing Contractor (SPC). Base support to the Shuttle program is provided by the Base Operations Contract (BOC) which is responsible for operations support functions such as printing and graphics, calibration of instrumentation, and evaluation, test and modification to launch support equipment, and other launch support services included in this budget are maintenance and repair of the central data subsystem, which supports both Shuttle processing as an on-line element of the launch processing system, range support provided by the DOD, Shuttle related data management functions such as work control and test procedures, and purchase of equipment, supplies and services not related to the Shuttle Processing Contractor.

The Payload and Ground Operations Control (PGOC) is the major contract for the payload processing activities including Spacelab and Space Station payload processing at KSC.

Launch operations funding in fiscal year 1988 provides for manpower and support services necessary for processing launches from KSC. This includes manpower to process the build-up of the SRB's, mate the boosters and tanks; process the orbiter; mate the orbiter to the integrated SRB's and tank; process and checkout integrated flight elements through launch; retrieve the SRB's for refurbishment; and support landing of the orbiter either at KSC or at a contingency landing site when required. Funding also supports the manpower required for sustaining engineering, spares provisioning, logistics, launch processing system operation and maintenance, and maintenance/modifications of all other Shuttle-related ground support equipment and facilities.

Payload and launch support funding provides propellants for launch operations and base support, and contractor support for the assembly of individual payloads into a total cargo.

Space Transportation Operations—Committee Comments

The Committee authorizes $1,885.8 million for Space Transportation Operations. This is the same as the President's budget request and reflects the Committee's strong support of activities critical to the restoration of the space shuttle fleet to flight status.

The Committee is very supportive of and most interested in the changes that are being made in the space shuttle launch and landing operations programs. Many of these changes stem from the recommendations of the Rogers Commission and the NASA Management Study Group and are designed to increase flight safety and to improve the launch decisionmaking process.

The Committee notes with concern the events surrounding the recent Atlas Centaur failure and hopes that NASA fully understands the importance of its personnel to any launch process. The Committee also expects to see a significant improvement in the weather forecasting capabilities and in the communications between Air Force and NASA personnel, along with a clarification of launch commit criteria for the Kennedy Space Center prior to the launch of any orbiter or expendable launch vehicle.

As noted in the prior section, the Committee anticipates additional fiscal year 1988 budgetary requirements for anomaly resolution activities, including Space Transportation Operations. The Committee, therefore, has provided "such sums as may be necessary" for these additional activities. It is the Committee's intent to include a specific amount for these activities before final action is completed on the fiscal year 1988 NASA Authorization Bill.

C. Space and Ground Networks, Communications and Data Systems—$944,900,000

The Committee authorizes $944,900,000 for fiscal year 1988 for ground networks, communications and data systems. This is $4 million less than the President's budget request.

Summary of fiscal year 1988 funding levels

Space Network	$481,500,000
Ground Networks	257,100,000
Communications and Data Systems	210,300,000
Total Space and Ground Networks, Communications and Data Systems	[1] $948,900,000

[1] The Administrator of NASA is given discretion to apply a general reduction of $4 million to this total amount of funding.

The purpose of this program is to provide vital tracking, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of the DOD, other Government agencies, commercial firms, and other countries and international organizations engaged in space research.

The Space Tracking and Data Network (STDN) will provide Earth orbital support until the Tracking and Data Relay Satellite System (TDRSS) becomes operational. At that time the STDN phase down will continue with the closure of several ground stations. The Deep Space Network (DSN) under the management of the Jet Propulsion Laboratory (JPL), provides support to geosynchronous, highly elliptical, and planetary and solar system exploration missions, as well as support to those spacecraft, now in low-Earth orbit, which are not compatible with TDRSS.

Space Network

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communications services to low Earth orbital spacecraft. The TDRSS itself, when fully operational, will consist of a three satellite constellation including an on-orbit spare in geostationary orbit and ground facilities located at White Sands, New Mexico. From the White Sands location, satellite and ground communication links interconnect the NASA elements of the network and any remotely located user facilities. The TDRSS can provide a nearly six-fold increase in the orbital coverage compared to the eight existing ground stations.

The fiscal year 1988 request includes funding for: repayment of the loans extended by the Federal Financing Bank for TDRSS development; maintenance and operation of the White Sands complex and other NASA elements of the network; support activities such as systems engineering, documentation and mission planning; equipment modification and replacement; analytical studies to define the spacecraft required for the next generation TDRSS; the procurement of an additional TDRS spacecraft and long-lead parts from TRW to replace the spacecraft lost in the *Challenger* accident and provide the option for an additional spacecraft; and the implementation of a second ground terminal at White Sands.

The TDRS-1 was launched in April 1983, and since that time it has supported Shuttle missions. The TDRS-2 was destroyed in the *Challenger* accident in January 1986. The *four remaining spacecraft* are undergoing modifications to be compatible with Shuttle safety requirements and are in various stages of construction, assembly and retesting. Launch of the next TDRS is expected to occur in June 1988 on the first Shuttle mission when flights resume. The launch date of the third TDRS is currently under review. Once these two spacecraft have been successfully launched and the system achieves operational status, TDRS-1 will become the on-orbit spare.

Due to the aging of the equipment and the necessary replacement of major subsystems and components in the existing TDRSS ground terminal, a second TDRSS ground terminal will eventually be required, necessitating an alternate means of conducting network operations while the replacement activity is underway. The addition of a second ground terminal will provide the necessary alternative means for continuing operational support while the existing terminal is down during the replacement.

At the same time, because the design of the current terminal is limited to full operation of two TDRS spacecraft, a second terminal will also provide the additional flexibility to operate more spacecraft if, as anticipated, NASA and DOD mission requirements exceed the two satellite operations capability in the mid-1990's.

Ground Networks

The Ground Networks provide support to three broad categories of missions: earth orbital spaceflight; planetary and solar system exploration; and aeronautics, balloons, and sounding rockets. Earth orbital support is provided primarily by the Spaceflight Tracking and Data Network (STDN), a network of eight geographically dispersed ground stations. The Deep Space Network, with ground stations located at three sites approximately 120 degrees apart in longitude, provides support to the planetary and solar system exploration missions as well as earth orbital missions not supportable by TDRSS. Aeronautics, balloons and sounding rocket research is supported by especially instrumented ranges as well as mobile systems.

Funding for the Ground Networks provides for operation and maintenance of the worldwide tracking facilities, engineering support, and the procurement of hardware and software to sustain and modify network capabilities. The workload in fiscal year 1988 will include support to the Space Shuttle and support to ongoing mis-

sions such as Dynamic Explorer (DE), International Ultraviolet Explorer (IUE), and Solar Maximum Mission (SMM). Preparations will be underway for the upcoming 1989 Voyage-Neptune encounter and future planetary missions including Galileo, Ulysses, Magellan, and Mars Observer. Aircraft test programs will also be supported.

The fiscal year 1988 request includes funds to operate all eight STDN stations and to upgrade equipment systems and subsystems at those facilities to be retained after TDRSS is operational. These facilities include the Merritt Island, Florida and Bermuda STDN stations which provide prelaunch, launch, and shuttle landing support, as well as limited orbital support. Also included is the orbital tracking facility at the Wallops Flight Facility which provides orbital tracking support.

The three Deep Space Network (DSN) complex locations—Goldstone, California; Canberra, Australia; and Madrid, Spain—are approximately 120 degrees apart in longitude to permit continuous viewing of planetary and solar system spacecraft. After completion of the project in 1988 to expand the diameter of the 64-meter antenna dishes to 70 meters, each complex will have four antennas: one 70-meter, two 34-meter and one 26-meter. A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) In Pasadena, California.

Communications and Data Systems

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control and data processing support.

Major activities underway include the implementation of: (1) a mission control and data capture system for the Hubble Space Telescope and (2) mission control and data processing capabilities for support of upcoming missions such as Spacelabs, Gamma Ray Observatory (GRO) and Upper Atmosphere Research Satellite (UARS) In addition, studies have been initiated to evaluate Space Station support requirements.

Space Tracking and Data Acquisition—Committee Comments

The Committee authorizes $944.9 million for Space Tracking and Data Acquisition for fiscal year 1988. This is $4 million less than the President's budget request. This reduction is a general reduction to be applied at the discretion of the Administrator.

The Committee is most supportive of NASA's Space Tracking and Data Acquisition program and is well-aware of the critical value of this program to the success of the nation's space program.

The Committee has fully authorized the fiscal year 1988 budget request for the replacement of the Tracking and Data Relay Satellite (TRDS) lost in the *Challenger* tragedy and feels that the deployment of this system is a high priority.

The Committe expects to be kept fully informed of any developments in this area and of any changes to the current program. Meanwhile, the Committee anxiously awaits the launch of a TDRS satellite on the first flight of the space shuttle in June 1988.

D. EXPENDABLE LAUNCH VEHICLE OPERATIONS—$100,000,000

The Committee authorizes $100,000,000 for fiscal year 1988 for expendable launch vehicle operations. No monies were requested for this activity by the President in his budget request. The Committee recognizes this initiative as a high priority and feels that NASA must have a mixed fleet capability.

Expendable Launch Vehicle Operations—Committee Comments

The Committee authorizes $100 million for Expendable Launch Vehicle Operations for fiscal year 1988 to initiate the procurement of expendable launch vehicles (ELVs). This line item is a "new start" initiated by the Committee in recognition of the need to expand the national launch capability and to preserve the space shuttle fleet for these critical missions that require its unique capabilities. The Administration requested no fiscal year 1988 funds for ELVs for NASA. However, NASA is currently preparing a fiscal year 1988 budget amendment for submission to the Office of Management and Budget for the procurement of expendable launch vehicle services. The Committee assumes the Administration will endorse this amendment since it provides funding for a critical national requirement.

Prior to 1984, the national policy was phase-out the government's use of ELVs and to rely upon the space shuttle for the launch of government payloads. At the end of 1985, this policy underwent a major revision when DOD expressed grave concerns about the lack of an alternative launcher to serve national security requirements. DOD then initiated the procurement of ten Complementary Expendable Launch Vehicles, now referred to as Titan IVs.

In the aftermath of the *Challenger* disaster, the fabric of the ELV policy has totally dissolved. The Air Force has doubled the procurement of Titan IVs, increased the refurbishment of Titan IIs, and entered into an agreement for an initial buy of 12 Delta IIs. DOD Also has submitted a fiscal year 1987 supplemental appropriations request for a Heavy Lift Vehicle or Advanced Launch System. Meanwhile, the only ELV procured by NASA in this same period has been a single Delta for the Cosmic Background Explorer Mission. Several comprehensive studies were conducted within and and outside of NASA highlighting the requirements for ELVs for civil payloads, and NASA's May 15 announcement of a plan to acquire ELV services for NASA missions is responsive to the conclusions of these studies.

In light of the convincing empirical evidence which reveals the need for NASA to maintain a Mixed Fleet capability, the Committee has initiated an Expendable Launch Vehicle Operations program in fiscal year 1988. The Committee also strongly endorses the proposed change to the fiscal year 1987 Operating Plan that would establish the framework for this initiative.

The Committee drew strongly upon the NASA Advisory Council "Report of the Task Force on Issues of a Mixed Fleet" and the Office of Space Flight "Report of the NASA Mixed Fleet Study Team" in proposing this new ELV initiative. In general, the Committee supports the recommendations and findings of both of these

reports and feels that they formulate a very pragmatic space transportation policy and recovery program for NASA.

The Committee feels strongly that in implementing its initiative, NASA should incorporate a diversified family of launchers into the NASA space flight program. The Committee also advises NASA that its budgeting and planning should be more realistic and not always based upon a best-case scenario. Some level of problem generation and stand-downs (whether post-accident or merely precautionary) should be assumed at the flight rate anticipated by NASA during the next decade.

The Committee was most pleased with NASA's May 15th announcement of a plan to acquire ELV services for NASA missions. The major objective of the NASA plan is to accelerate the deployment of the Nation's backlog of space science missions—an initiative whole heartedly endorsed by the Members of this Committee.

Despite the fact that a formal request has yet to be submitted to the Committee, the Committee agrees in principal with the recently announced NASA plan and is pleased that NASA may augment existing DOD ELV contracts as well as secure separate launch services agreements. While the Committee generally requires NASA to utilize a competitive procurement process for the acquisition of hardware or services, it would endorse a limited noncompetitive procurement of ELVs in the near-term to best match available ELVs and already designed payloads and mission requirements.

The Committee feels that its ELV initiative is a critical element of the Nation's space transportation restoration program and an important first step toward the creation of a robust Mixed Fleet.

III.—CONSTRUCTION OF FACILITIES—$210,700,000

The Committee authorizes $210,700,000 in fiscal year 1988 for the Construction of Facilities. This is $15.2 million more than the President's budget request.

The Construction of Facilities (CoF) appropriation provides contractual services for the repair, rehabilitation and modification of existing facilities; the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects, and advance planning related to future facilities needs.

The funds requested for 1988 provide for: the continuation of prior year endeavors in meeting the facilities requirements for Space Flight and the Space Station Programs; modification of aeronautical research and develop facilities; repair, rehabilitation and modification of other facilities to maintain, upgrade and improve the usefulness of the NASA physical plant; minor construction of new facilities; facility planning and design activities; and environmental compliance and restoration.

The projects and amounts in the budget estimate reflect Space Flight requirements that are time sensitive to meet specific milestones. Other program requirements for 1988 include the construction of a spacecraft systems development and integration facility as well as modifications for utility reliability at the Goddard Space Flight Center; construction of an integrated test facility at Dryden Flight Research Facility; modifications to the Hypersonic Propul-

sion Facility for Vacuum Systems at the Langley Research Center; construction of an addition to the Research Analysis Center and modifications for Fan/Compressor Research to the Engine Research Building at the Lewis Research Center; and the construction of a Communications Development Antenna at Goldstone, California.

The fiscal year 1988 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and ensuring safe economical and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program begun in prior years and continues a repair program. The purpose of the repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements. The Environmental Compliance and Restoration Program will assure that statutory environmental requirements will be met and any necessary remedial action promptly taken.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies and the preparation of facility project design drawings and bid specifications.

The $210,700,000 authorized for Construction of Facilities projects in fiscal year 1988 is for the following activities:

(1) Construction of LC 39 Operations Support Building, Kennedy Space Center, $17,000,000;

(2) Construction of Spacecraft Systems Development and Integration Facility, Goddard Space Flight Center, $8,600,000;

(3) Modifications for utility reliability, Goddard Space Flight Center, $2,900,000;

(4) Construction of Integrated Test Facility, Dryden Flight Research Facility, $10,500,000;

(5) Modifications to Hypersonic Propulsion Facility for Vacuum Systems, Langley Research Center, $3,100,000;

(6) Construction of addition to the Research Analysis Center, Lewis Research Center, $9,800,000;

(7) Modifications for Fan/Compressor Research, Engine Research Building, Lewis Research Center, $6,500,000;

(8) Construction of Communications Development Antenna, Goldstone, California, Jet Propulsion Laboratories, $6,400,000;

(9) Repair of facilities at various locations, not in excess of $750,000 per project, $25,000,000;

(10) Rehabilitation and modification of facilities at various locations, not in excess of $750,000 per project, $32,000,000;

(11) Minor construction of new facilities and additions to existing facilities at various locations, not in excess of $500,000 per project, $8,000,000;

(12) Environmental compliance and restoration, $23,900,000;

(13) Repair and modernization of the 12-foot pressure wind tunnel at the Ames Research Center, $41,000,000; and

(14) Facility planning and design not otherwise provided for, $16,000,000.

Construction of Facilities—Committee Comments

The Committee authorizes $210.7 million for Construction of Facilities activities in fiscal year 1988. This increase of $15.2 million to the President's budget requet is the result of two specific actions by the Committee.

First, without prejudice, the Committee has decided to delay the initiation of space station facilities activities until fiscal year 1989. This one year delay is consistent with the revised schedule that NASA has formulated and with the Space Station Program Office's facilities requirements. The proposed delay affects four projects and results in a fiscal year 1988 savings of $25.8 million.

Second, the Committee has provide an additional $41 million in fiscal year 1988 to initiate Phase I of the repair and modernization of the 12 foot pressure wind tunnel at the NASA Ames Research Center.

The 12 foot pressure wind tunnel, constructed in 1944, has been one of the world's premier subsonic wind tunnels and has played a major role in the development of every U.S. commercial and military aircraft design since 1960. During a recent inspection of the pressure shell, major cracks were discovered, and the wind tunnel's use was greatly restricted to prevent a catastrophic failure. At present, the tunnel is of no real value to industry or the development of aircraft such as the Boeing 767, the McDonnell Douglas MD-11, and DOD's Advanced Tactical Fighter.

The Committee strongly supports the repair and modernization of this facility in a timely manner and feels it is a national priority. The Committee instructs NASA to initiate Phase I activities in fiscal year 1988 with an anticipated completion date of March 1991. The design monies for these activities should be provided in fiscal year 1988 pursuant to a provision contained in the pending fiscal year 1987 Supplemental Appropriations bill.

Meanwhile, review of these two changes being prescribed by the Committee has surfaced another issue—the overall health and well-being of the infrastructure of our civil aeronautical and space program. While a great deal of time and energy has been focused on R&D programs and transportation systems, the Committee fears that the rehabilitation and modernization of the facilities critical to the success of these programs have not kept pace with the R&D programs and transportation systems. It is with great anticipation, therefore, that the Committee awaits submission of NASA's Five Year Plan for Construction of Facilities, and is hopeful that NASA will recognize the importance of rehabilitation and modernization of these facilities.

IV.—RESEARCH AND PROGRAM MANAGEMENT—$1,608,000,000

The Committee authorizes $1,608,000,000 for fiscal year 1988 for Research and Program Management, including the $10 million authorized in Title II for the National Space Grant College and Fellowship Program. This is $10 million more than the President's budget request which reflects the inclusion of the Space Grant College and Fellowship Program initiative.

The Research and Program Management appropriation provides funds for the performance and management of research, technology and test activities at NASA installations, and the planning, management and support of contractor research and development tasks necessary to meet the Nation's ongoing objectives in aeronautical and space research. The objectives of the activities funded by the Research and Program Management appropriation are to (1) provide the civil service staff with the technical and management skills to conduct the full range of programs for which NASA is responsible, (2) provide base maintenance of facilities and manage its use in support of research and development programs, and (3) provide effective and efficient technical and administrative support for the research and development programs .

The Research and Program Management appropriation provides funding for the 22,425 permanent and temporary civil service workyears (FTE) at eight major installations and Headquarters—an increase of 625 FTE from 1987. This civil service workforce is NASA's most important resource and is vital to future space and aeronautics research activities. About seventy percent of the Research and Program Management appropriation provides for the salaries and related costs of this civil service workforce. Three percent of this appropriation is used for travel, critical to manage successfully the agency's in-house and contracted programs. The remaining amount of the Research and Program Management appropriation provides for the research, test and operational facility support, and for related goods and services necessary to operate efficiently and effectively the NASA installations and to accomplish NASA's approved missions.

NASA field centers report to the Program Associate Administrator responsible for the major portion of their technical programs. The principal roles assigned to each installation, based on demonstrated capabilities and capacities to meet NASA's overall program goals, are as follows:

Office of Space Flight

Johnson Space Center.—Management of the Space Shuttle program, including orbiter production and operation; selection and training of astronauts and mission specialists; Space transportation System Operations including mission planning, operational procedures and flight control; and management of the selected Space Station hardware and subsystems development and operations planning and definitions.

Kennedy Space Center.—Launch of Space Shuttle flights; management of the ground operational phase of the Space Transportation System; the preparation and launch of payloads on the Space Shuttle and expendable launch vehicles, and Space Station operational readiness planning.

Marshall Space Flight Center.—Management of the Space Shuttle main engine, solid rocket booster and external tank projects; management of NASA's activities on the Spacelab project; management of large automated spacecraft projects such as the Hubble Space Telescope; conduct and development of experiments in materials processing in space; and management of selected Space Station hardware and subsystems.

National Space Technology Laboratories.—Space Shuttle engine testing; Earth resources research and technology transfer; and provision of support service functions for other government agencies located on site.

Office of Space Science and Applications

Goddard Space Flight Center.—Development and operation of Earth orbital flight experiments and automated spacecraft to conduct scientific investigations and demonstrate practical applications; management of tracking and data acquisition activities; management of the Delta Launch vehicle program; management and launch of sounding rockets and balloons; operation of an instrumented flight range for aeronautical and space research; and development of the Space Station platforms and payload accommodations. The Wallops Flight Facility is an operational element and component installation of the Goddard Space Flight Center.

Office of Aeronautics and Space Technology

Ames Research Center.—Conduct of activities involving experimental and theoretical aerodynamics research, computational fluid dynamics, aeronautical flight research and testing, rotocraft technology, short and vertical takeoff and landing technology, technology for transatmospheric vehicles, planetary probe research, life sciences, human factors, autonomous systems, guidance and control, and operation of an alternate landing site for the space shuttle operational missions. The Dryden Flight Research Facility, and operational element and component installation of Ames located in the Mojave Desert, is the site of advanced flight testing and shuttle landings.

Langley Research Center.—Conduct of subsonic aircraft research and technology, emphasizing fuel conservation, safety and environmental effects; hypersonic propulsion; experimental and theoretical aerodynamics; environmental quality monitoring by remote sensing; advanced space systems technology; and research in the areas of structures and materials, guidance and controls, and airframe/propulsion integration of the transatmospheric research and technology program.

Lewis Research Center.—Conduct of aeronautical and space propulsion research and technology, including propulsion for the transatmospheric research and technology program; space communications research and technology; space energy systems research and technology; development of the space station power system; and management of expendable launch vehicle programs.

The fiscal year 1988 budget request for Research and Program Management provides for (1) personnel and related costs, including the full year cost of January 1987 pay raise and the estimated cost to implement the new Federal Employees Retirement System (FERS); (2) travel; and (3) the operations of NASA installations including facilities services, technical services and management and operations.

Research and Program Management—Committee Comments

The Committee authorizes $1,598.0 million for Research and Program Management in fiscal year 1988. In addition, the Committee has authorized $10 million additional in Title II to accommodate the initiation of the National Space Grant College and Fellowship Program in fiscal year 1988. The total amount of funding available to NASA, therefore, is $1,608.0 million.

The Committee has long felt that NASA's key asset has been its talented and dedicated managers, scientists, and engineers. However, the Committee fears that not enough emphasis has been placed by NASA or the Congress on developing the next generation of qualified scientists and engineers, as more than 56 percent of NASA's current technical base are civil servents over age 45.

To address this deficiency, the Committee has included the provisions of the National Space Grant College and Fellowship Program Bill, S. 752, as Title II of S. 1164, the fiscal year 1988 NASA Authorization Bill. The principal purposes of this act are to:

(1) increase the understanding, assessment, development, and utilization of space resources by promoting a strong educational base, responsive research and training activities, and broad and prompt dissemination of knowledge and techniques;

(2) utilize the capabilities and talents of the universities of the Nation to support and contribute to the exploration and development of the resources and opportunities afforded by the space environment;

(3) encourage and support the existence of interdisciplinary and multidisciplinary programs of space research within the university community of the Nation, to engage in integrated activities of training, research and public service, to have cooperative programs with industry, and to be coordinated with the overall program of the National Aeronautics and Space Administration;

(4) encourage and support the existence of consortia, made up of university and industry members, to advance the exploration and development of space resources in cases in which national objectives can be better fulfilled than through the programs of single universities;

(5) encourage and support Federal funding for graduate fellowships in fields related to space; and

(6) support activities in colleges and universities generally for the purpose of creating and operating a network of institutional programs that will enhance achievements resulting from efforts under this act.

To accomplish these objectives, the Administrator of NASA is provided an additional $10 million authorization in fiscal year 1988, to be equally divided between the (1) space grant college program and (2) the new space fellowship program.

As provided for in the amendment offered by Senator Danforth to S. 1164, the "Administrator shall not under this title designate any space grant college or space grant regional consortium or award any fellowship, grant, or contract unless such designation or award is made in accordance with the competitive, merit-based review process employed by the Administration, i.e., National Aero-

nautics and Space Administration, on the date of enactment of this Act."

In implementing the Danforth Amendment, the Committee expects NASA to apply Section 107 of the bill to the Space Grant College and Fellowship Program (Section 107 of the bill instructs NASA to consider distributing its research and development funds on a geographical basis, where feasible).

The Committee recognizes that a conflict may exist between the Danforth amendment and any desire to distribute grants, awards, and fellowships on a geographical basis. The intent of the Danforth amendment is to ensure that Federal tax dollars are spent in the most efficient and productive manner possible. Furthermore, this amendment recognizes the government's responsibility to the taxpayer to ensure that the award of grants, contracts, and fellowships are made to the most competent and qualified individuals and universities possible. Yet, the Committee recognizes the benefits of developing a broader university space research infrastructure. Therefore, the Committee expects to be kept informed as to the award of contracts, grants, and fellowships under the Space Grant College and Fellowship Program and the manner in which they are awarded.

The Committee also instructs NASA to utilize the Space Grant College and Fellowship Program to broaden, where practical and desirable, the range of universities involved in space related research and development activities and to distribute these fellowships across a broad range of disciplines. The intent of the Space Grant College and Fellowship Program is not to concentrate activities among a few centers of higher education and their graduate students. The purpose of the program is to utilize the capabilities and talents of the universities of the entire Nation and to increase the understanding, assessment, development, and utilization of space resources by promoting a strong educational base.

Title II of S. 1164 is not specific as to whether the Space Grant College and Fellowship Program should be funded from within NASA's existing research and education program funds or as an augmentation to NASA's budget. While S. 1164 accommodates the College and Fellowship Program as an augmentation to NASA's existing research and education program funds, it is the Committee's intent that in future years the College and Fellowship Program should, likewise, not be funded from within NASA's existing research and education program funds.

The Committee is pleased to see the augmentation of critical skills in the NASA workforce with the addition of 625 new civil service job slots in the fiscal year 1988 budget request. These additional slots should greatly increase the safety, reliability, and quality assurance capabilities and engineering skills of the agency.

For fiscal year 1988, the Committee earmarks $250,000 of the funds authorized for Research and Program Management for activities associated with organizing the national and international aspects of the International Space Year (ISY). These monies are to be divided equally between NASA's Office of External Relations and the Office of Space Science and Applications.

Office of Commercial Space Transportation—Section 108

The Committee has authorized $4,550,000 for the operation of the Office of Commercial Space Transportation within the Department of Transportation in Section 108 of S. 1164. This is the same as the President's budget request and is consistent with the provisions of S. 1173, the Administration's fiscal year 1988 budget request that was included in the NASA Authorization bill.

The Office of Commercial Space Transportation was established pursuant to Public Law 98-575, with the specific purpose of initiating the regulatory activities necessary for commercial space transportation operations. These activities include safety research and planning, licensing procedures, inspection operations and risk management.

In light of the advent of the marketing of commercial launch services by U.S. firms, this Office should face increased requirements in fiscal year 1988 in order to accommodate the approval of these launches. For this reason, the Committee provides the Administration's request. However, the Committee expects to see an increase in technical proficiency of this Office as a result of the significant increase over the fiscal year 1987 operating plan.

The Committee is also concerned about the delay in the final approval of the range use agreement with the U.S. Air Force. This agreement is essential to the success of any commercial launch effort. The Committee, therefore, expects to be informed of any impediments which may exist to prevent the formal completion of this agreement. The Committee is sensitive to the complexity of the issues surfaced by such an agreement and feels strongly that the final agreement must both protect U.S. interests and assist this nascent industry. Once again, it is clear that government/industry cooperation is required if a commercial launch industry is to emerge.

National Aeronautics and Space Council—Section 109

Section 109 of the bill authorizes the reestablishment of a National Space Council within the Executive Office of the President. The Council would be composed of the Vice President as Chairman, the NASA Administrator, and the Secretaries of State, Defense, Commerce, and Transportation. The functions of the Council would be to advise the President on all space policy matters and to coordinate civilian space activities with national security space activities.

In addition, a nine member User Advisory Group would be created and would provide advice on space policy from the perspective of the users. The Group would be composed of nine non-federal representatives from aerospace, science and other related fields and shall from time to time meet with the Chairman.

The Council also would be assisted in performing its duties and functions by a professional staff of not more than seven members.

A provision identical to Section 109 of the fiscal year 1988 NASA Authorization was included in the fiscal year 1987 NASA Authorization bill that was agreed to by the House of Representatives but vetoed by the President in the 99th Congress. One of the bases for the veto was the inclusion of the National Space Council in the Authorization bill and a belief on the part of the President that the

language impinged on his authority over the composition of the Executive Office of the President. This language was reintroduced in the 100th Congress as S. 504, by Senators Riegle, Hollings, Gore, Kerry, Rockefeller, Adams, Pressler, and Bentsen.

The Committee has included this language as a reflection of its deep concern about the lack of effective space policymaking in the government. The National Security Council has nominal control over interagency space policy but has failed on several occasions to provide adequate direction, focus or coordination. Our national space program is a resource and endeavor that warrants and deserves the highest priority within the Administration. Moreover, decisions and policies affecting our space program must be made in a timely and responsible manner. The Committee's concern is related to the difficulty, over the past two to three years, of our space policymaking process to resolve effectively and in a timely manner particular issues that have been crucial to the conduct of our civilian space program.

At the time this provision was originally included in the fiscal year 1987 NASA Authorization bill, the Committee was deeply concerned about a space policymaking apparatus that placed the respective agency interests above the national interests. The events surrounding the shuttle pricing policy decision, the commercialization of expendable launch vehicles, and the determination to procure a replacement orbiter for the space shuttle *Challenger*, pointed to an unacceptable deficiency that had to be corrected. The Presidential veto of the fiscal year 1987 NASA Authorization bill, however, precluded a legislative remedy to this problem.

Since the time of the Presidential veto, November 14, 1986, the situation has not improved. The confusion associated with the cost, schedule and configuration of the space station program and the fiscal year 1987 supplemental request for a heavy lift launch vehicle (HLLV), now referred to as an Advanced Launch System, manifests the same symptoms that were of concern to the 99th Congress. The existing space policymaking apparatus seems incapable of resolving conflicts in a timely manner. The existing space policymaking process either has to be altered dramatically or a new process, with greater visibility and a dedicated staff, needs to be established. This Committee supports the latter option and feels the appropriate starting point is the exact same language that was vetoed by the President.

The Committee believes that actions must be taken now to create more coherence and consistency to the civilian space program. It is impossible for several different agencies within the government to maintain independent space programs. The costs in terms of inefficiency and budget are simply too great. In the Committee's opinion, a National Space Council, under the direction of the Vice President, could produce a more rational and balanced space policy. The Council performed a function similar to this during the early days of the space program with great success. In addition, the Council may elevate space and issues to a much higher level of interest and visibility than in recent years and thereby cast these issues in terms of a national priority.

The Committee recognizes that the establishment of the Council will not, in and of itself, remedy all of the existing problems within

the space program. It could, however, provide the necessary focus, motivation and policymaking framework to resolve the current difficulties, allocate resources in a sensible fashion, and provide the impetus to move the space program toward future successes.

Amendment to the National Aeronautics and Space Act of 1958 to Authorize the Acceptance of Gifts and Donations—Section 110

S. 503 would permit NASA to accept conditional gifts and donations from private citizens and corporations. This bill was introduced on February 5, 1987, by Senators Riegle, Hollings, Gore, Kerry, Rockefeller, Nickles, Danforth, Pressler, and Bentsen.

The bill would permit citizens to contribute to a specific activity within NASA, such as the construction of the new space shuttle. Currently, such donations cannot be accepted and dedicated strictly to one purpose. The need for this legislation emerged in the aftermath of the *Challenger* disaster when NASA was receiving contributions from various groups, organizations and individuals to buy a new orbiter. Presently, there are roughly $29,000 in this category, primarily the result of the Nickels for NASA program.

In addition, the bill would require that the new name for the orbiter be selected from names submitted by school children who spearheaded them fund raising effort with the Nickels for NASA program.

To facilitate consideration of this amendment in a timely fashion, S. 503 has been incorporated into S. 1164, the fiscal year 1988 NASA Authorization bill, as Section 110.

International Space Year—Committee Comments

The International Space Year (ISY), which will extend from 1992 through 1994, is an initiative of the United States Congress that has gained support from NASA, the President, foreign nations, and International scientific organizations. For the past two years, Congress has urged NASA to intensify its efforts on behalf of them ISY; and NASA, in association with the National Academy of Sciences and other relevant agencies, has been successful in laying a solid foundation for the ISY in the United States and abroad. ISY planning committees have been established in many nations, including the United States and the other major space powers. The International Committee on Space Research (COSPAR) and its parent body, the International Council of Scientific Unions (ICSU), the chief coordinating agent for the immensely successful International Geophysical Year (IGY) of 1957–58, have established ISY coordinating committees. The ISY's promising evolution offers positive testimony to United States' leadership in world space activities.

The Committee strongly supports the ISY and has earmarked $250,000 in the Research and Program Management account to assist in the organization of the national and international aspects of the ISY.

Title II—National Space Grant College and Fellowship Program
Committee Comments

Title II of the bill establishes the National Space Grant College and Fellowship Program and authorizes $10 million for each of fiscal years 1988 and 1989 and $15 million for each of fiscal years 1990 and 1991 to carry out this new program. The purpose of this program is to promote activities in colleges and universities that will increase the understanding, assessment, development and utilization of space resources, and expand the educational, scientific and research base in all space-related fields.

The Committee has found that NASA's currents to attract and recruit scientists and engineers to fill its ranks is sporadic and ineffective. In the 1960's NASA supported an average of 500 doctoral students per year. The current program supports about 80 students. More than 56 percent of NASA's engineers and scientists, for example, are over the age of 45. Thus, it is clear that NASA is not creating nor maintaining a base of talent to draw upon as the older generation nears retirement.

NASA's professional corps has been the single most important factor in the successes of our space program. Throughout the early years, thousands of the nation's brightest minds came to NASA to be a part of that historic effort. The Committee is deeply concerned that NASA has lost the ability to attract the diversity and the caliber of scientists and engineers vital to the success of the future space program.

To address this deficiency, the Committee has included the National Space Grant College and Fellowship Program in the fiscal year 1988 NASA Authorization bill. The Committee has modeled this program after the Sea Grant college program, which has been a successful multidisciplinary effort involving the academic, governmental, and industrial communities. The Sea Grant program has produced a cadre of young scientists dedicated to marine-related issues. The Committee believes that this approach can also be successful in space activities. The language requires that grants provided by NASA be matched by private contributions. This will ensure a continuing level of interest and participation by a broad spectrum of our nation in the space program.

Thus, the Committee is most anxious to begin the implementation of this program. The legitimate concerns of NASA have been addressed, with respect to administrative flexibility. Other concerns with respect to regional balance are also reflected in the language of the title.

The Committee strongly believes that the National Space Grant College and Fellowship program will be an important step in our common effort to revitalize the nation's space program.

During markup of the NASA Authorization bill, an amendment to the Space Grant College and Fellowship Program was proposed by Senator Danforth and accepted. The exact language contained in this amendment and the Committee's interpretation are contained in the Committee Comments for Research and Program Management.

The Final Space Grant College and Fellowship Program provisions contained in Title II of this bill are identical to those contained in S. 752, with the exception of the Danforth Amendment.

Title III—Amendments to the Land Remote Sensing Commercialization Act of 1984

S. 502, a bill to amend the Land Remote Sensing Commercialization Act of 1984, was introduced on Februrary 5, 1987, by Senators Riegle, Hollings, Gore, Kerry, Rockefeller, Adams, and Bentsen.

This bill consists of technical amendments to the Land Remote Sensing Commercialization Act that would clarify the Congressional intent with regard to the distribution of experimental data and its use by research and development organizations. The bill also would permit system operators to restrict the reproduction or dissemination of unenhanced data by foreign or domestic users.

The same language as contained in S. 502 was passed by the House and Senate during the 99th Congress. Unfortunately, this bill was incorporated into the fiscal year 1987 NASA Authorization bill that was vetoed by the President.

To facilitate consideration of these amendments in a timely fashion. S. 502 has been incorporated into S. 1164, the fiscal year 1988 NASA Authorization bill, as Title III.

ESTIMATED COSTS

In accordance with paragraph 11(a) of rule XXVI of the Standing Rules of the Senate and section 403 of the Congressional Budget Act of 1974, the Committee provides the following cost estimate, prepared by the Congressional Budget Office:

U.S. CONGRESS,
CONGRESSIONAL BUDGET OFFICE,
Washington, DC, May 21, 1987.

Hon. ERNEST F. HOLLINGS,
Chairman, Committee on Commerce, Science, and Transportation, U.S. Senate, Dirksen Senate Office Building, Washington, DC.

DEAR MR. CHAIRMAN: The Congressional Budget Office has prepared the attached cost estimate for S. 1164, the National Aeronautics and Space Administration Authorization Act of 1988.

If you wish further details on this estimate, we will be pleased to provide them.

With best wishes,
Sincerely,

EDWARD M. GRAMLICH,
Acting Director.

CONGRESSIONAL BUDGET OFFICE COST ESTIMATE

1. Bill number: S. 1164.

2. Bill title: National Aeronautics and Space Administration Authorization Act of 1988.

3. Bill status: As amended and ordered reported by the Senate Committee on Commerce, Science, and Transportation on May 14, 1987.

4. Bill purpose: This bill authorizes the appropriation of an estimated $9,961 million in fiscal year 1988 for the ongoing activities of the National Aeronautics and Space Administration (NASA). In addition, the bill initiates the National Space Grant College and Fellowship program within NASA and authorizes the appropriation of $10 million in each of fiscal years 1988 and 1989 and $15 million in fiscal years 1990 and 1991 for the making of grants under that program.

The fiscal year 1988 authorization specified in the bill for NASA totals $9,621 milion. The bill also authorizes the appropriation in fiscal year 1988 of such sums as may be necessary to return the shuttle fleet to flight status. Of the specified authorization, $3,721 million is for research and development, $4,081 million is for space flight, control, and data communication, $211 million is for construction of facilities, and $1,608 million is for research and program management.

In addition to the NASA authorizations, the bill authorizes the appropriation of about $4.6 million for the Office of Space Commercialization in the Department of Transportation. The bill also amends the Land Remote-Sensing Commercialization Act of 1984.

5. Estimated cost to the Federal Government: The following table shows funding amounts specifically authorized by S. 1164 and estimated outlays based upon these amounts.

[By fiscal years, in millions of dollars]

	1988	1989	1990	1991	1992
Specified authorization level:					
Function 250: Civilian space	8,854.9	10.0	15.0	15.0	.....
Function 400:					
Aeronautics	766.1	.....	.....	.....	.....
Commercial space	4.6	.....	.....	.....	.....
Total specified authorizations	9,625.6	10.0	15.0	15.0	.....
Estimated outlays	6,507.8	2,764.5	678.6	47.0	16.1

In addition, the bill authorizes the appropriation of such sums as may be necessary in fiscal year 1988 to return the shuttle system to operational flight status. Based upon preliminary information, the estimated authorization level and estimated outlays associated with this requirement would be as shown in the table below.

[By fiscal years, in millions of dollars]

	1988	1989	1990	1991	1992
Estimated authorization level	350.0	.....	.....	.....	.....
Estimated outlays	246.8	81.9	21.3	.....	.....

The table below shows the total authorization and outlay levels for S. 1164.

[By fiscal year, in millions of dollars]

	1988	1989	1990	1991	1992
Total authorization levels (specified and estimated)	9,975.6	10.0	15.0	15.0	
Total estimated outlays	6,754.6	2,846.4	700.0	47.0	16.1

Including outlays from previous years' appropriations, total NASA outlays in fiscal year 1988 are estimated to be $9,996 million, assuming appropriation of the amounts authorized in this bill.

The costs of this bill fall within budget functions 250 and 400.

Basis of estimate: The authorization levels in the first table are the amounts specified in the bill. The outlay estimates for ongoing programs assume that all funds authorized are appropriated prior to the beginning of fiscal year 1988 and that spending will reflect historical patterns. The outlay estimates for new programs assume that spending will follow historical patterns of similar government programs.

The fiscal year 1988 authorization level required to return the shuttle system to flight status is a CBO estimate based upon preliminary information. Estimated outlays are assumed to follow historical spending patterns for shuttle system operations.

6. Estimated cost to State and local governments: None.

7. Estimate comparison: None.

8. Previous CBO estimate: None.

9. Estimate prepared by: Paul M. DiNardo.

10. Estimate approved by: James L. Blum, Assistant Director for Budget Analysis.

Regulatory Impact Statement

In accordance with paragraph 11(b) of rule XXVI of the Standing Rules of the Senate, the Committee provides the following evaluation of the regulatory impact of the legislation.

Primarily, this bill authorizes the appropriation of funds for the conduct of space and aeronautical research and development activities to carry out the policy and purpose of the National Aeronautics and Space Act of 1958. These activities are conducted in NASA laboratories, by NASA personnel and through contracts with industry, universites, and research institutions for research and development and for supporting scientific and technical services. The Committee has concluded that the nature of these activities is such that there is no regulatory effect on individuals and businesses and no effect on individual privacy.

The bill also authorized the appropriation of funds for the Office of Commercial Space Transportation in the Department of Commerce and establishes a National Space Grant College and Fellowship Program. The Office of Commercial Space Transportation licenses and regulates the commercial expendable launch vehicle industry in order to protect the public health and safety and comply with existing United States treaty and international law obligations. This office was created to reduce the regulatory burden and paperwork requirements on the industry, and the Committee's action represents the reauthorization of an existing program.

As for the National Space Grant College and Fellowship Program, it builds on an existing NASA program and does not represent a burdensome regulatory regime. Recipients of the grants, awards, contracts, or fellowships will be expected to comply with the guidelines that are promulgated.

The Office of Commercial Space Transportation and the National Space Grant College and Fellowship Program have no effect on individual privacy and should not have an unacceptable regulatory effect on the individuals or businesses who choose to participate.

None of the above mentioned programs would have an inflationary impact, and the only additional paperwork requirement would be the submission of applications for the National Space Grant College and Fellowship Program.

Section-by-Section Analysis

TITLE I

SECTION 101

The short title of title I is the "National Aeronautics and Space Administration Authorization Act, 1988".

SECTION 102

This section authorizes $9.621 billion for the National Aeronautics and Space Administration in fiscal year 1988.

These monies are distributed to four appropriations accounts:

1. *Research and Development.*—$3.721 billion for space station, space science and applications, space transportation capability development, commercial programs, aeronautical research and technology, transatmospheric research and technology and space research and technology.

The major assumptions in this area are full funding for the space station in fiscal year 1988, restoration of funding for the Advanced Communications Technology Satellite program, and initiation of a new Civilian Space Technology Initiative.

2. *Space Flight Control and Data Communications.*—$4.081 billion for space shuttle production and operations capability, space transportation operations, space tracking and data acquisition, and expendable launch vehicle operations.

The major assumptions in this account are deferral of funding for the structural spares program for a fifth orbiter pending further assessment of the expendable launch vehicle program and the new advanced launch system program; and initiation of a ELV procurement program at NASA for NASA payloads that would be based on a quid pro quo with the Air Force or a launch service agreement with a commercial operator.

3. *Construction of Facilities.*—$0.210 billion for a variety of repair, rehabilitation and new construction activities required for a robust civilian space program.

The major assumptions in this account are that the space station facilities can be delayed one year because the overall program has been delayed for that period of time, and the priority status of repairing the 12 foot wind tunnel at the NASA

Ames Research Center. This tunnel is critical to both civil and military aircraft development.

Subsection (h) of this account is also amended to permit NASA to expend up to $500,000 for modifications to GSA-controlled facilities. Formerly the cap was $100,000 but this precluded upgrading the health care unit and auditorium at NASA Headquarters.

4. *Research and Program Management.*—$1.598 billion for all civil service staff, maintenance of facilities and support of R&D programs and contract activities, and technical and administrative support of research and development programs.

The major assumptions in this account are that NASA will increase the civil service employee base by 625 new slots and that the Space Grant College and Fellowship program will be initiated in fiscal year 1988. Of these new jobs, 270 are for Headquarters, 25 for the Inspector General's Office, 128 for the Johnson Space Center, 27 for the Kennedy Space Center, 160 for the Marshall Space Flight Center, and 15 for the National Space Technology Lab.

SECTIONS 103, 104, AND 105

These sections establish strict parameters for the Administrator of NASA concerning the amount of flexibility he/she has with construction of facilities activities, the transfer of funds from one account to another, and the use of funds for activities not approved by the Committee. These provisions are included in the NASA Authorization bill each and every year.

SECTION 106

This section reiterates the Committee position that the space station may be used only for peaceful purposes. This language is consistent with existing U.S. treaty obligations (the Outer Space Treaty) and current law—P.L. 99-170. This language permits DOD research and development activities on the space station.

SECTION 107

This section instructs NASA to distribute its research and development funds on a geographical basis where possible. The Committee annually legislates this requirement and feels it is in the national interest.

SECTION 108

This section authorizes $4.55 million for fiscal year 1988 for the Office of Commercial Space Transportation in the Department of Transportation. This Office oversees the regulation and licensing of commercial expendable launch vehicle activities and was established by this Committee pursuant to P.L. 98-575—the Commercial Space Launch Act. The level authorized is the Administration's request.

SECTION 109

This section amends the National Aeronautics and Space Act of 1958 to reestablish the National Space Council. The Council would

be located within the White House and chaired by the Vice-President. It would include the representatives of NASA, and the Departments of Defense, State, Commerce, and Transportation. It would be the function of the Council to advise the President on space policy matters and to coordinate civilian activities with those in the national security arena. This section also provides for the creation of a nine member (non-Federal) User Advisory Group that would meet with the Vice President at least once a year and gives the Council the authority to employ a staff of not more than seven persons.

The Council provision was included in last year's NASA Authorization bill that was vetoed by the President.

SECTION 110

This section amends the National Aeronautics and Space Act of 1958 to permit the Administrator of NASA to accept conditional gifts and donations for the construction of a new space shuttle orbiter.

Currently, NASA may not accept conditional gifts. However, in the aftermath of the space shuttle *Challenger* accident, thousands of persons made donations to NASA that have been placed in a bank account. The current estimates of these "conditional" donations is $19,000.

SECTION 111

This section indicates that it is the Sense of the Congress that the U.S. must promptly restore its space transportation capabilities, and such restoration must be accomplished without deemphasizing other space programs.

This section also instructs the Administrator of NASA to take such steps as necessary to return the space shuttle fleet safely to flight status.

Section 111 also authorizes "such sums as may be necessary" to meet these requirements.

NASA is currently in the porocess of reviewing *additional* fiscal year 1988 shuttle anomaly resolution and Rogers Commission recommendations that have not been funded in Section 102 of this bill. This review is not likely to be completed until the end of May and then a budget amendment will need to be prepared, approved and submitted to the Congress.

In anticipation of this request, the Committee has included the "such sums language" with the intent of inserting the dollar value of the additional requirements if approved by the subcommittee, in the bill on the floor of the Senate or in Conference. This language gives the Committee this option and does not preclude discussion of this matter in Conference.

SECTION 112

This section authorizes multi-year contracting authority for launch services in order to avoid violation of the Anti-Deficiency Act, 31 U.S.C. 1341 *et seq.*, and similar fiscal or other laws and regulations which limit the monetary obligation or the contract period. Generally, NASA's non-construction appropriations cover

no more than two fiscal years. The budget and appropriation process provides funding on an incremental basis and does not include sufficient funding to fully fund such launch service contracts which foreseeably could require advance payments over several years for the construction of the vehicle, and then provide the services for a program that could cover a decade. Normally payments for the services could not be made until the services are rendered. In such situations the termination liability for the construction costs alone could exceed the incremental funding provided in the initial fiscal period appropriation.

The provision to limit launch services to domestic companies is intended to foster privatization by providing NASA the necessary authority to limit the procurement of launch services to U.S. firms when this is in the public interest. Furthermore, this section would allow NASA to contract over periods of time and on terms and conditions which are necessary if those domestic firms are to undertake the investment and assume the risks inherent in preparing for services that will not be provided for serveral years hence. Accordingly, this section authorizes NASA, consistent with its charter to seek and encourage the fullest commercial use of space (42 U.S.C. 2451(c)), to limit the solicitation and award of such contracts to domestic U.S. firms, provided it is deemed in the public interest. The proviso does not make it mandatory to contract only with domestic firms regardless of any countermailing circumstances, although it is expected to have that effect until a domestic commercial launch industry is firmly established. Without the authority given in this section, the full and open competition requirements of the Competition in Contracting Act of 1984, P. L. 98-369, and related or similar laws and regulations could impair the development of the domestic launch services industry.

TITLE II

SECTION 201

This title may be cited as the "National Space Grant College and Fellowship Act".

SECTION 202

The Congress finds that NASA, through the National Space Grant College and Fellowship Program, can best promote commitment and interest in the understanding and development of space.

SECTION 203

This section notes the purposes of the Act. The principal purpose is to support activities in colleges and universities that will increase the understanding, assessment, development, and utilization of space resources by promoting a strong educational base, responsive research and training activities.

SECTION 204

This section contains the definitions that are used in the proposal.

SECTION 205

This section instructs the Administrator of NASA to establish and maintain a national space grant college and fellowship program to provide financial assistance, and to establish long-range planning guidelines and priorities, and to adequately evaluate the program.

This section also gives the Administrator the authority to accept conditional and unconditional gifts to fund these activities, to accept and use Federal funds from other Federal programs and to issue rules and regulations as may be necessary and appropriate.

SECTION 206

This section grants the Administrator the authority to make grants and enter into contracts to assist any space grant college and fellowship program if it supports the purposes of the act set out in section 203. It also limits the amount of any grant or contract to 66 percent of the proposed program except in special circumstances.

SECTION 207

This section instructs the Administrator to identify specific national needs and problems relating to space and to make grants or enter into contracts with respect to such needs and problems. There is no cap on the NASA share of these activities.

SECTION 208

This section grants the Administrator the authority to designate any institution of higher education as a space grant college and any association or other alliance of two or more persons, other than individuals, as a space grant regional consortium.

This section also establishes the requirements needed to be fulfilled to obtain such designations, including a balanced program of research education, training and advisory services related to space.

SECTION 209

This section instructs the Administrator to support a space grant fellowship program for qualified individuals at the graduate level of education in fields related to space.

The total amount for space grant fellowships shall not exceed 50 percent of the total funds appropriated pursuant to this title.

SECTION 210

This section instructs the Administrator of NASA to establish an independent committee known as the Space Grant Review Panel to assist the Administrator in formulating applications and proposals for grants and contracts, the space grant fellowship award, the designation and operation of space grant college and regional consortium, the formulation and application of planning guidelines, etc.

SECTION 211

This section permits other Federal agencies to provide personnel, services, and facilities on a reimbursable basis or otherwise to assist in carrying out the provisions of this title.

SECTION 212

This section requires the Administrator to submit an annual report to the Congress and the President on the activities of the national space grant college and fellowship program.

SECTION 213

This section requires the Administrator to utilize the competitive, merit-based review employed by the Administration on the date of enactment of this Act in designating any space grant college or space grant regional consortium or in awarding of any fellowship, grant, or contract.

SECTION 214

This section authorizes $10 million for the program for each of fiscal years 1988 and 1989, and $15 million for the program for each of fiscal years 1990 and 1991.

TITLE III

SECTION 301

This title may be cited as the "Land Remote Sensing Commercialization Act Amendments of 1987".

SECTION 302

The Congress finds that it remains strongly committed to the act and that flexibility is required in carrying out the provisions of the original act.

SECTION 303

This section states the purposes of these amendments are to ensure implementation of the act in a most effective manner and to clarify the original intent where there was confusion.

SECTION 304

This section amends the act to make an exception for unenhanced data gathered through R&D programs and activities. This section of the act deals with the contractual arrangement between the Federal Government and EOSAT and the marketing of unenhanced data.

SECTION 305

This section permits the Secretary of Commerce to dispose of government assets in a manner that best ensures the continuation of the contractor's commercial activity.

SECTION 306

This section permits Federal agencies that gather data through research and development programs to make this remote sensing data available to research and development programs funded by the Federal Government. The original act created some confusion on this point.

SECTION 307

This section permits any system operator to provide data for research and development programs if there is a complete and timely disclosure of the results of the research or if the system operator submits an annual report on such activities to the Secretary of Commerce.

SECTION 308

This section further indicates that a system operator may require that unenhanced data not be reproduced or disseminated by any foreign or domestic purchaser.

Title III was included in the fiscal year 1987 NASA Authorization bill that was vetoed by the President. Basically, these provisions are meant to clarify the original act and to eliminate uncertainties that have arisen with the interpretation of the act.

CHANGES IN EXISTING LAW

In compliance with paragraph 12 of rule XXVI of the Standing Rules of the Senate, changes in existing law made by the bill, as reported, are shown as follows (existing law proposed to be omitted is enclosed in black brackets, new material is printed in italic, existing law in which no change is proposed is shown in roman):

THE NATIONAL AERONAUTICS AND SPACE ACT OF 1958

Section 201 of that Act

SEC. 201. (a) There is hereby established, in the Executive Office of the President, the National [Aeronautics and] Space Council (hereinafter called the "Council") which shall be composed of—

(1) the Vice President, who shall be Chairman of the Council;

(2) the Secretary of State;

(3) the Secretary of Defense;

(4) the Secretary of Transportation;

(5) the Administrator of the National Aeronautics and Space Administration; and

(6) the Chairman of the Atomic Energy Commission[.] *who shall be the Vice Chairman of the Council; and*

(7) such other members as the President may appoint.

[(b) The President shall from time to time designate one of the members of the Council to preside over meetings of the Council during the absence, disability, or unavailability of the Chairman.]

(b) In the absence of the Vice President, the Administrator shall preside over meetings of the Council.

[(c) Each member of the Council may designate another officer of his department or agency to serve on the Council as his alternate in his unavoidable absence.]

(c) Each member of the Council may designate an officer of their department or agency to serve on the Council as their alternative in their unavoidable absence.

(d) Each alternate member designated under subsection (c) of this section shall be designated to serve as such [by and with the advice and consent of the Senate] unless at the time of his designation he holds an office in the Federal Government to which he was appointed by and with the advice and consent of the Senate.

(e) It shall be the function of the Council to advise and assist the President, as he may request, with respect to [the performance of functions in the aeronautics and space field, including] the following functions:

[(1) survey all significant aeronautical and space activities, including the policies, plans, programs, and accomplishments of all departments and agencies of the United States engaged in such activities;

[(2) develop a comprehensive program of aeronautical and space activities to be conducted by departments and agencies of the United States;

[(3) designate and fix responsibility for the direction of major aeronautical and space activities;

[(4) provide for effective cooperation among all departments and agencies of the United States engaged in aeronautical and space activities, and specify, in any case in which primary responsibility for any category of aeronautical and space activities has been assigned to any department or agency, which of those activities may be carried on concurrently by other departments or agencies; and

[(5) resolve differences arising among departments and agencies of the United States with respect to aeronautical and space activities under this Act, including differences as to whether a particular project is an aeronautical and space activity.]

(1) survey of ongoing civilian space activities;

(2) review of long-range goals for civilian space activities;

(3) coordination of civilian space activities among civilian agencies and with agencies involved in national security space activities; and

(4) interagency cooperation in civilian space activities.

(f) * * *

(g)(1) The Council shall establish a Users' Advisory Group composed of nine non-Federal representatives of industries and other persons involved in space activities.

(2) The Vice President shall name a Chairman of the Users' Advisory Group.

(3) The Council shall from time to time, but not less often than once a year, meet with the Users' Advisory Group.

(4) The function of the Users' Advisory Group is to ensure that the interests of non-Federal entities involved in space activities, including in particular commercial entities, are adequately represented in the Council.

SEC. 202.-207. * * *

DONATIONS FOR SPACE SHUTTLE ORBITER

SEC. 208. (a) The Administrator may accept gifts and donations of services, money, and real, personal, tangible, and intangible property, and use such gifts and donations for the construction of a space shuttle orbiter.

(b)(1) The authority of the Administrator to accept gifts or donations pursuant to subsection (a) of this section shall terminate five years after the date of the enactment of this section.

(2) All gifts and donations accepted by the Administrator pursuant to subsection (a) of this section which are not needed for construction of a space shuttle orbiter shall be used by the Administrator for an appropriate purpose—

(A) in tribute to the dedicated crew of the space shuttle Challenger; and

(B) in furtherance of the exploration of space.

(c) The name of a space shuttle orbiter constructed in whole or in part with gifts or donations whose acceptance and use are authorized by subsection (a) of this section shall be selected by the Administrator of the National Aeronautics and Space Administration from among suggestions submitted by students in elementary and secondary schools.

Title III of that Act

SEC. 301.-310. * * *

CONTRACTS REGARDING EXPENDABLE LAUNCH VEHICLES

SEC. 311. (a) Notwithstanding any other provision of law, the Administrator may enter into contracts for expendable launch vehicle services that are for periods in excess of the period for which funds are otherwise available for obligation, provide for the payment for contingent liability which may accrue in excess of available appropriations in the event the Government for its convenience terminates such contracts, and provide for advance payments reasonably related to launch vehicle and related equipment, fabrication and acquisition costs if any such contract limits the amount of the payments that the Federal Government is allowed to make under such contract to amounts provided in advance in appropriations Acts. Such contracts may be limited to sources within the United States when the Administrator determines that such limitation is in the public interest.

(b) If funds are not available to continue any such contract, the contract shall be terminated for the convenience of the Government, and the costs of such contract shall be paid from appropriations originally available for performance of the contract, from other, unobligated appropriations currently available for the procurement of launch services, or from funds appropriated for such payments.

THE COMMERCIAL SPACE LAUNCH ACT

Section 24 of that Act

AUTHORIZED APPROPRIATIONS

SEC. 24. There are authorized to be appropriated to the Secretary $4,000,000 for fiscal year 1985. There is authorized to be appropriated to the Secretary to carry out this Act $586,000 for fiscal year 1986. *There is authorized to be appropriated to the Secretary to carry out this Act $4,550,000 for fiscal year 1988.*

THE LAND REMOTE-SENSING COMMERCIALIZATION ACT OF 1984

Section 202 of that Act

CONTRACT FOR MARKETING OF UNENHANCED DATA

SEC. 202. (a) In accordance with the requirements of this title, the Secretary, by means of a competitive process and to the extent provided in advance by appropriation Acts, shall contract with a United States private sector party (as defined by the Secretary) for the marketing of unenhanced data collected by the Landsat system. Any such contract—

(1) shall provide that the contractor set the prices of unenhanced data;

(2) may provide for financial arrangements between the Secretary and the contractor including fees for operating the system, payments by the contractor as an initial fee or as a percentage of sales receipts, or other such considerations;

(3) shall provide that the contractor will offer to sell and deliver unenhanced data to all potential buyers on a nondiscriminatory basis;

(4) shall provide that the contractor pay to the United States Government the full purchase price of any unenhanced data that the contractor elects to utilize for purposes other than sale, *except in the case of research and development activities conducted in accordance with section 504*";

(5) shall be entered into by the Secretary only if the Secretary has determined that such contract is likely to result in net cost savings for the United States Government; and

(6) may be reawarded competitively after the practical demise of the space segment of the Lansat system, as determined by the Secretary.

(b)-(d) * * *

Title III of that Act

SEC. 301.-307. * * *

DISPOSITION OF GOVERNMENT ASSETS

SEC. 308. Following the completion of a contract made pursuant to this title, the Secretary may, upon 30 days advance notice to the Committee on Commerce, Science and Transportation of the Senate and the Committee on Science and Technology of the House of Representatives, dispose of assets (other than real property) under the

control of the Secretary in a manner which best ensures the continuation of the contractor's commercial activity.

Title V of that Act

Section 502 of that Act

[USE OF EXPERIMENTAL DATA

[SEC. 502. Data gathered in Federal experimental remote-sensing space programs may be used in related research and development programs funded by the Federal Government (including applications programs) and cooperative research programs, but not for commercial uses or in competition with private sector activities, except pursuant to section 503.]

RESEARCH AND DEVELOPMENT ACTIVITIES OF FEDERAL AGENCIES

SEC. 502. Each Federal agency is authorized and encouraged to provide data gathered in experimental remote-sensing space programs to related research and development programs funded by the Federal Government (including application programs) and to cooperative research programs if the Federal agency involved determines that the data will not be used—

(1) for any commercial purpose, or

(2) in substantial competition with data available from a licensee under this Act,

except pursuant to section 503.

SEC. 503. * * *

RESEARCH AND DEVELOPMENT ACTIVITIES OF SYSTEM OPERATORS

SEC. 504. Notwithstanding section 601, any system operator under title II, III, or IV of this Act, or any marketing entity under section 503 of this Act, may provide data for any research and development programs if—

(1) a complete and timely disclosure of the results of such research and development is made in the open technical literature or is otherwise made publicly available;

(2) the system operator or marketing entity provides to the Secretary an annual report of all research and development data transactions including the nature of any cooperative agreement and the prices charged for data; and

(3) the data are not used for commercial purposes or in substantial competition with data available from a licensee under the Act.

Title VI of that Act

[NONREPRODUCTION

[SEC. 602. Unenhanced data distributed by any system operator under the provisions of this Act may be sold on the condition that such data will not be reproduced or disseminated by the purchaser.]

NONREPRODUCTION

SEC. 603. In addition to such other terms and conditions as the system operator may set forth in compliance with section 601 of this act, the system operator may require that unenhanced data not be reproduced or disseminated by any foreign or domestic purchaser.

ADDITIONAL VIEWS OF MR. ADAMS

The American space program, and the agency which runs it, are clearly in trouble. The *Challenger* disaster revealed technical and administrative weaknesses; our response to that tragedy has demonstrated a continuing inability to correct identified deficiencies in both the operation and the design of our space program.

This bill should help us correct some of those problems. I am pleased that the Committee has increased funding for, and emphasis on, expendable launch vehicles; I am also pleased that we have denied funding for a fifth shuttle. While I believe we could have gone further in each of those areas, I am satisfied that we have at least begun to deal with some of the basic questions which need to be addressed. As we move further away from the trauma of the *Challenger,* I believe we will be able to more objectively examine these issues and make even more dramatic shifts in strategy.

We need to make dramatic strategic shifts because, if the space program continues on its present course, it will fail. And that, I believe, would be a disaster. Space exploration is an economic, scientific, and psychological necessity for this nation. But this vital program will not be able to secure the funding it needs in the furture unless it is able to regain the support of the public in the present.

That support was not lost as a result of the *Challenger* accident; after all, the space program has suffered other setbacks in the past. No, public dissatisfaction seems to spring from a sense that the program has lost its vision. The American space program is now seen as being run by technocrats whose goal is to meet military needs; it must once again be perceived as a program headed by visionaries who understand the practical consequences of their action, but are driven by a quest for knowledge and a love of adventure.

In that context, we all recognize that there are practical consequences associated with space activity. The Soviet superiority in space is disturbing: their space station is allowing them to gain knowledge that we should have; their Expendable Launch Vehicles may allow them to enter a market we could have monopolized; their proposed planetary missions will give them a view of the cosmos which we must share. But a desire to "keep up" with the Soviets is not enough to ensure either public support or government funding. In fact, the uncertain relationship which currently exists between DOD and NASA raises profound questions about the nature of the program—and those doubts will need to be resolved in the near future. My point is simply that our space efforts must be motivated by more than a desire to compete with the Soviets; it must also be driven by a desire to compete with the best in ourselves.

In my view, the most critical decision facing NASA in the near future is not related to the ultimate design of the space station—

though that is clearly a major issue—but rather to the nature of its ultimate mission. The recent resignation of at least one critical decision-maker engaged in evaluating the future options is not a good sign in this respect, but the process must continue. NASA must produce a vision for the future which takes the space program to the edge of the unknown once again.

At one point, NASA sought to depict shuttle flights as routine ventures. That was a mistake. The reality is that no flight into space is routine. Space is not an extension of the human environment. It is a hostile area which will not forgive mistakes. It is precisely that characteristic which makes exploration so necessary and gives it the potential to be so inspiring. NASA's decision about the direction it wishes to take will, to a large extent, determine just how willing the Congress and the country will be to fund its ventures.

While I endorse this basic thrust of this authorization, and while I remain committed to a strong space program, I simply wanted to take this opportunity to issue a warning: in a period of fiscal restraint, NASA needs to give us more than another mode of transportation—it must demonstrate that it has the imagination to transport us to the frontiers of human knowledge. Hopefully their internal efforts, and this bill, will help produce just such a result.

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